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PROBLEMS OF FARM FISH POND MANAGEMENT

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In many countries, fish culture has long been regarded as a means of food production. In the United States, fishermen are interested in the sporting aspects rather than the food value of fishes, as fishing for sport has become an inalienable right of the common man. More people fish than engage in any other type of sport, and this includes spectator participation in competitive sports.

Since the middle of the 19th century, scientists here have been concerned about the depletion of fishery resources as a result of pollution, improper forestry practices, stream obstructions, soil erosion, and other causes. This concern led to the formation of the American Fish Culture Association in 1870 and to the establishment of the U. S. Commission of Fish and Fisheries 2 years later. Farm fish ponds have been built in such tremendous numbers in recent years that they are providing fishing where none existed before, and are supplementing public fishing waters.

The first fish ponds in this country probably were mill ponds where an individual could pass the time with hook and line as he waited to have his grain ground. Some of these ponds are being managed today.

Gradually farm ponds, constructed to provide water for livestock, became important as fish ponds. Interest in the management of these ponds became evident about the turn of the century and increased during World War I. The drought period of the 1930's and the consequent attention to the conservation of soil and its fertility gave impetus to the farm-pond construction program. To stimulate soil conservation practices, agricultural conservation agencies stressed the use of farm ponds as fish and wildlife habitat and for recreation, as well as for stock-watering, water storage, irrigation and fire protection.

Many of the principles of construction and management of fish ponds have been known for decades. Francis (1883) pointed out that productivity of a body of water is limited by the food produced, and overpopulation results in the deterioration of fishing. Certain requirements for managing farm ponds noted by Stranahan (1902) are applicable today: the need for core trenching for the dam, and means of draining the pond; the use of largemouth black bass (*Micropterus salmoides*), marble catfish (*Ameiurus nebulosus*), and bluegill sunfish (*Lepomis macrochirus*) or rock bass (*Ambloplites rupestris*), under given conditions, for stocking the pond; adequate harvest;

and a stocking rate designed to avoid overpopulation.

The writings of Townsend (1914), Dyche (1914), Johnson and Stapleton (1915), Embody (1915), and Barney and Canfield (1922) reflected the added emphasis upon farm ponds for the production of fish during a period when the need for greater production of protein foods was recognized.

The management measures developed since 1934 by H. S. Swingle, Dr. E. V. Smith and associates, for farm fish ponds in the Southeast have been applied in many parts of the country. There has been a gradual realization, however, that methods of fish-pond management applicable to Alabama do not necessarily apply elsewhere. Dissatisfied pond owners have caused state organizations to undertake investigations to adapt fish-pond management to local ecological, climatic, land-use, and farm-practice situations. Undoubtedly the availability of Dingell-Johnson funds will stimulate research in this field in the future.

Stocking rates that have proved satisfactory in new fish ponds consist of 100 bass and from 750 to 1,500 bluegill fingerlings per acre. Where 1,500 bluegills are used, they will be somewhat smaller when harvested. The Fish and Wildlife Service in 1944 established the rate of 100 bass and 1,000 bluegills per acre as a compromise. For unfertilized waters, one-half of that number is used, as no rate has been established.

Many states have established stocking rates applicable to local conditions. Where these have been demonstrated to be well founded, the Service has followed state recommendations. In the Southwest, the Service policy is to stock at the unfertilized rates unless the applicant will actually fertilize the pond.

Although the bass-bluegill combination is the one most widely used, other species are often stocked in combination with these or alone. In waters too cold for warm-water species, or where the success of spawning of these species may be questionable, trout are generally stocked. Turbid waters which will not permit bass and bluegills to grow may be stocked with white crappie or some species of bullhead or catfish. The following is a list of species most commonly used in various stocking combinations by the states.

Rainbow trout	—*Salmo gairdnerii*
Eastern brook trout	—*Salvelinus fontinalis*
Channel catfish	—*Ictalurus lacustris*
Brown bullhead	—*Ameiurus nebulosus*
Black bullhead	—*Ameiurus melas*
Spotted black bass	—*Micropterus punctulatus*
Largemouth black bass	—*Micropterus salmoides*
Bluegill sunfish (bream)	—*Lepomis macrochirus*
Redear sunfish	—*Lepomis microlophus*
Warmouth	—*Chaenobryttus coronarius*
Rock bass	—*Ambloplites rupestris*
White crappie	—*Pomoxis annularis*
Black crappie	—*Pomoxis nigromaculatus*

Most of the stocking rates recommended by state biologists include such combinations as 100 bass and 200 bluegills per acre, 200 to 200, or other similar ratios, but may include a variety of combinations of species. Species other than bass or bluegill may replace some percentage of one or the other or may supplement the bass-

bluegill combinations. The use of species other than the bass-bluegill combination is not satisfactory because they either overpopulate the pond or disappear from the population. These other species are used because of popular demand, and there seems to be no reason why research cannot develop species combinations that would meet local needs. In a few cases adult fish are used to stock new ponds.

Since 1947, the Fish and Wildlife Service has inspected hundreds of farm ponds in all parts of the United States. As the history and stocking rates of most of these ponds are known, the success or failure of individual ponds can be analyzed. These analyses point up the major problems in different sections of the country. A few of these problems will be discussed briefly.

In such States as Colorado and Arizona, where water is valued primarily for its use in irrigation, ponds are pumped full and partly drained to irrigate crops during a 24-hour period. Irrigation ponds fluctuate as much as 10 feet, and the water is cold. Good fish ponds are rare, and studies must be made of fish production in these ponds and in highly mineralized waters. Present stocking rates do not work. On the other hand, ranch tanks—unfertilized and used daily by cattle—often produce good fishing. The ponds producing good fishing are considered as being "in balance."

A balanced fish population is one which is productive of catchable-sized fish in satisfactory amounts and in proportion to fertility of the water. The balance can be determined by sampling the population to find out whether there is a proper ratio of catchable-sized fish to small fish, and whether the ratio of predatory to non-predatory species is such as to indicate that the fish are growing rapidly.

Inspections of ponds in the Southwest revealed that, of approximately 217 ponds inspected, the following were in balance: 64.5 percent of those of 0.5 to 2 acres; 60 percent of those 8 feet or more in depth; 51 percent of ponds having water bloom; 55 to 61 percent of the slightly cloudy or clear ponds; and 61 percent of the ponds where water fluctuation was 1 foot or less. Over much of North Dakota and the other north-central border states, most ponds less than 12 feet deep suffer winterkill, and it is recommended that minimums of 16 feet in depth and 2 acres in size be maintained. In Indiana, small size (0.5 to 2 acres) of ponds appears to be a favorable factor, as only 45 percent of larger ponds had balanced populations of fishes.

A comparison of fertilized and unfertilized ponds in the Southwest, where 178 ponds stocked on a fertilized basis were studied, showed that 35 actually were fertilized and 95 (53.4 percent) were in balance. Of 39 stocked on an unfertilized basis, 64.5 percent were in balance. Inspections of 217 ponds in the eastern Great Plains showed 45.5 percent of unfertilized and 69 percent of fertilized ponds in balance. Among ponds having 10 percent or more of the bottom covered with submerged vegetation, 61.5 percent were in balance, while only 45.5 percent having less vegetation were in balance. In the Southeast, 207 of 323 ponds investigated were out of balance and only 65 were fertilized enough to control weeds. Of these latter, 80 percent were in

balance; while only 25 percent of the unfertilized ponds were in balance. Of 418 problem fish ponds, 90 percent were unfertilized.

In the Southwest, most of the ponds stocked more than 3 years prior to inspection were out of balance. In many sections of the western Plains States, where only 39 of the 114 ponds inspected were in balance, the majority of ponds were overpopulated with bluegills and bullheads, which had been stocked at the owners' request. Winterkill, uncontrolled livestock use, and wind action, as well as underfishing, contribute to the failure of many ponds. Where there is owner interest in pond management, most ponds provide excellent fishing.

More attention should be given to the use of predators other than bass in pond management. A few Montana ponds, in which lack of balance had resulted from light and selective fishing, were test-stocked by the Service with northern pike and were brought into balance within a year. Suitable species combinations for initial stockings in ponds such as these should be developed.

In Indiana, 82 percent of the ponds stocked with 200 bass and 200 bluegills per acre were in balance. As mentioned previously, small ponds appeared to be a favorable factor. In many instances, particularly in the Southwest, initial stocking was too heavy to permit ponds to come into balance. Of another group of 110 ponds inspected in the South, only 27 percent offered good to excellent fishing.

This, in general, covers the sections of the country where major farm fish-pond programs have been undertaken. In the Pacific Coast States, limited suitable waters and lack of a source of warm-water species for stocking have hindered the program somewhat. The New England and Middle Atlantic States have farm fish-pond programs, but much of the stocking there has involved trout. The Fish and Wildlife Service has not investigated these ponds.

The results of surveys of existing farm fish ponds by members of the Service lead us to believe that the major problems in successful management of farm fish ponds in various parts of the country are as follows:

1. Stocking rates based upon ecological and climatic conditions, fishing preferences, carrying capacity of waters, and fishing intensity, should be developed for various sections of the country. Stocking rates are needed for unfertilized as well as fertilized waters.

2. As underfishing is a nationwide condition, ponds should be stocked at an unfertilized rate (to be determined) and fertilization should be encouraged only where fishing intensity is sufficient to keep the population in balance. Fertilizer should be used only if enough is applied annually to control vegetation.

Probably the greatest factor contributing to underfishing is state regulation. Although about one-third of the states permit the landowner, and in some cases the tenants, to fish farm ponds without a license, only about seven states will permit capture of these fish with devices other than hook and line. Four or five states permit the sale of fishes propagated in farm ponds, but the commercial dealer's fee is often too high for the average farmer to make use of the privilege.

Most states still have restrictions on

the number of fish that may be taken and seasonal regulations for public waters which must be followed in farm ponds. This limitation on fishing is surprising in view of the overwhelming evidence that most fish ponds which are unsuccessful fail because of underfishing. All other farm practices are permitted and encouraged on a scientific cropping basis.

Less than a dozen states do not stock farm ponds, although some of these states permit the Fish and Wildlife Service to do it. In three states certain warm-water species are not permitted to be stocked—primarily to prevent trout habitat from becoming infected with species which eventually become a nuisance.

It appears, from the studies made so far, that state regulations must be drastically changed if the farm fish-pond program is to succeed. Unlimited cropping and scientific management, on the same basis as other farm crops, must be encouraged in order to maintain populations of fishes in balance and to utilize the crop to the maximum. The evidence is overwhelming that those states having unrestricted fishing for species taken in farm ponds contain a higher percentage of successful farm ponds than is found anywhere else in the country.

3. Drastic fluctuations of pond levels should be avoided, and ponds should be constructed deep enough to prevent winterkill.

4. Programs should be developed by fisheries technicians for cooperative work with district conservationists, county agents, and other people responsible for land-use projects. The objective should be to educate these groups in proper methods of fish-pond construction and proper management procedures.

5. In some parts of the country a "bloom" is not essential to a successful fish pond, and this phase of management needs further study.

6. Additional investigations should be made of muddy ponds in the western Plains States. Soil conditions are conducive to suspended silt even with good soil conservation. Present studies point the way to the possible removal of suspended matter and to the establishment of species combinations that will provide a reasonable amount of fishing where silt cannot be removed.

Inspections of farm fish ponds by the Service have shown the fallacy of attempting to apply to all parts of the country the same criteria for construction, the same stocking recommendations, and the same management procedures. There is question as to the desirability of a general recommendation on fertilization. Service workers have come to the conclusion that management practices should be tailored to local conditions, and that stocking should be determined by the natural carrying capacity of a pond.

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FARM AND RANCH PONDS

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The multiple-purpose farm pond, carefully located, scientifically designed and properly built, is a commonplace element in today's rural scene. This, however, has not always been so. Not many years ago, farm ponds were scarce. They were used mainly for watering livestock and occurred primarily in areas where springs or wells or streams were inadequate for that purpose. Most of them were shallow, muddy and small. Because they had not been correctly located, designed or built, many washed out and others periodically went dry. Some had been stocked with fish but it was the rare one that produced the sizes and quantities that the landowner expected. Few met the specifications that we now consider important for successful fishponds.

Raising fish is one of the uses for farm ponds and thousands of them have been built for that use alone. Most, however, are built to provide a dependable supply of water for livestock, irrigation, fire protection, orchard spray, or for a combination of these and other uses. It is necessary to review the development of the present day farm pond in order to understand its development as a fishpond and its value to other wildlife.

Soil and water conservation and land-use programs that got under way in the 1930's are responsible for the widespread interest in ponds shown during the past 15 to 20 years. These programs emphasized pond building because in many places ponds make it possible to control erosion and to obtain much needed adjustments in land use. For example, the retirement from cultivation of badly eroded fields and of other lands not suitable for cultivation is often best done by establishing permanent grass cover. This results in increased acreage of pasture which frequently cannot be utilized by livestock because of the absence of watering places. Farm ponds provide the necessary water and permit a farmer to make this change in land use and to continue his farm as an economic unit.

As another example, inadequate and poorly distributed stock water has been one of the obstacles to obtaining proper utilization of forage in the ranching country of the west. Good range without

stock water cannot be used, whereas areas with water have often been overused. The development of stockwater ponds makes it possible to balance the grazing pressure between such areas and obtain proper use on both.

The building of ponds has reached considerable magnitude. Two bureaus in the United States Department of Agriculture assist farmers and ranchers to construct them. The Soil Conservation Service, working through local soil conservation districts, provides technical assistance on site selection, design, construction, use and maintenance. The Agricultural Conservation Programs Branch of the Production and Marketing Administration makes conservation payments to farmers and ranchers for the construction of ponds that are to be used primarily for soil and water conservation. Under recent arrangements, the Soil Conservation Service also provides the necessary technical assistance on ponds for which conservation payments are made.

In the fourteen years from 1937 to June 30, 1951, the Soil Conservation Service provided technical assistance to farmers and ranchers in the construction of 215,435 ponds. From 1936 to the end of 1950, the Production and Marketing Administration made payments for the construction of 823,797 ponds for livestock water. At the present time the Soil Conservation Service is assisting farmers to construct ponds at the rate of about 38,000 a year. In 1950, the Production and Marketing Administration made payments on 59,600 stockwater ponds. An unknown number have been built without assistance from either SCS or PMA.

In the summer of 1950, the Fish and Wildlife Service of the U. S. Department of Interior estimated that there were then about 1,576,000 farm and ranch ponds. At present (Jan. 1952) it is conservatively estimated that there are 1,666,000. The fact that widespread interest in farm ponds is a recent development in agriculture was well illustrated by H. S. Swingle, who in 1949 stated that in the previous 15 years there had been constructed in the United States at least 100 times as many ponds as had been constructed during the preceding 200 years.

The idea that the farm pond could also be used as a fishpond is not new in the United States. For at least 50 years prior to 1940, intermittent attempts were made to interest farmers in producing fish. The point was made repeatedly that a fishpond provides an interesting and nutritious addition to the farm diet, that it provides recreation in the form of fishing, swimming, boating, and skating, and that the pond itself is a thing of beauty that in many ways adds to the pleasures of farm life. In 1872 the first funds were appropriated for the Federal Government to make free distribution of fish for stocking purposes. There is also a long history of free distribution by States. In spite of these efforts, few farmers seriously tried to raise fish.

Four factors operated for years to prevent the farm fishpond idea from really catching on. First, there were no successful and easily applied methods for managing a fishpond. Second, practical "grass-root" ways of taking the idea to the farmer had not been used. Third, suitable ponds were the exception rather than the rule. Fourth, technical guidance in location, design, and construc-

tion of ponds was not easily available to farmers.

The last two of these factors that had worked against the widespread establishment of fishponds were eliminated by the appearance of the conservation programs previously discussed. Through these programs both technical guidance and financial aid were brought to farmers and ranchers for the construction of ponds. The result was that thousands of well-built ponds became available for use as fishponds.

The research done by H. S. Swingle and E. V. Smith at the Alabama Agricultural Experiment Station provided the simple and successful procedure of fishpond management that had been needed. With the publication of their work it became possible to make definite recommendations as to species, number and size of fish to be stocked, kind and rate of fertilization, mode of harvesting the crop, and other aspects of managing a pond for the production of warm-water fish.

Biologists in the Soil Conservation Service saw in the procedure developed by Swingle and Smith an opportunity to help farmers and ranchers get additional benefits from the ponds that they were building. Technicians of this Service were instructed in the fundamentals of fishpond management—how to build, stock, fertilize and otherwise manage a fishpond. Working through local soil conservation districts, they carried this knowledge—first in the Southeast and later throughout the nation—to thousands of farmers and ranchers. The Agricultural Extension Service and State Game and Fish Departments were also instrumental in popularizing fishponds and helping farmers establish them. Only with the assistance and cooperation of the U. S. Fish and Wildlife Service and the State Game and Fish Departments was it possible to start and to have continued the development of farm fishponds. Through the efforts of these agencies, farm ponds were and continue to be carefully stocked with the required numbers and kinds of fish.

A good fishpond calls for certain features not always found in farm ponds. The water level must be reasonably stable. A continuous flow of water through the pond is undesirable because it makes it difficult to maintain a high level of productivity. If the farm family is to get an appreciable amount of fish from it, the pond should have an area of not less than 1/4 acre. In warm climates the depth of water at the deepest part should be at least 6 feet; in cold climates depths of 10 to 12 feet are needed. To discourage the growth of weeds, the shore should slope steeply to 3 feet below the water level. A permanent drain is desirable so that the pond can be emptied if it becomes necessary to clean or restock it.

None of these requirements prevents a pond that is being used to produce fish from also being used as a source of water for livestock, and other farm purposes. Nevertheless, there are a few reservations about the use of fishponds. If livestock are allowed unrestricted access to them, their trampling will flatten the shore and make the water muddy. A flat shore can cause a weed problem and muddy water lowers the productivity of the pond. Grazing also destroys wildlife food and cover. These difficulties can be prevented by fencing the pond and piping stock-water to a trough below the dam. Ponds that are

used for storage of irrigation water are subject to considerable fluctuation in water level and often present problems when used as fishponds. Even these have, however, been successfully managed. (Fuqua, 1947).

Farm ponds may have some beneficial effects upon the control of floods and the recharge of ground waters, but these are probably of minor importance. Farm ponds are intended to be permanent sources of water and the cost of construction must be commensurate with the value received by the farmer. These restrictions limit their effectiveness in flood control and recharge of ground water. As a permanent source of water, a pond must have an impervious basin so that it will not leak. Special efforts are made, such as rolling and packing, to make it impervious. A pond that does not leak does not contribute much to the ground water.

The belief that farm ponds have an appreciable effect upon flood control comes about through the misunderstanding of the operation of flood control reservoirs. For a reservoir to operate successfully in flood control, it must aid in reducing peaks in flood flow. This is done by first catching runoff water, then releasing it slowly to the stream channel system. Flood control reservoirs are therefore built to have large temporary storage capacity but have only a small permanent pool. Farm ponds are built upon different principles. They are intended to stand full or nearly full of water at all times and all excess runoff is immediately released through the spillway. A farm pond has its greatest flood control value when it is empty, but when empty it is of little use to a farmer.

The value of farm and ranch ponds to birds and mammals is at present difficult to fully appraise. Although several studies are in progress, only a few have been reported upon. Water is essential to many forms of wildlife and they utilize that which is provided by farm ponds. In many parts of the arid and semi-arid regions of the West and Southwest, these ponds provide permanent and accessible water where such water did not previously exist. In the humid parts of the United States, they bring better distribution of water and reduce the seriousness of droughts.

That farm ponds are of value to wildlife is well illustrated by the use made of them by migratory waterfowl. A 1950 aerial survey of the part of South Dakota west of the Missouri River showed that in this area of 39,000 square miles there were about 40,000 man-made impoundments which contained about 100,000 acres of water, and which harbored 141,000 ducks. (Murdy, 1950). The conclusion was: "Thus, through the construction of stock dams a new breeding population is building up on the west-river ranges—a population that in 1950 contained 23 percent of the ducks in South Dakota." In Colorado, New Mexico and Texas, Allan (1939) found bluewinged teals, mallards, pintails and ruddy ducks nesting near and raising their young on ranch ponds. Eleven such ponds in Colorado supported a summer duck population of 107 birds, 73 of which were young. On five ponds, each with a water area of not more than one acre, a total of fifty young ducks were raised. Allan also recorded the use of small ponds by ducks, geese and shorebirds, during periods of migration. Similarly,

in many other parts of the West, ponds have made new habitat for waterfowl.

Waterfowl are not the only kinds of wildlife that are benefited by farm ponds. Following a study of muskrat population in 40 farm ponds in Missouri, Shanks and Arthur (1951) stated: "Without question, the thousands of farm ponds throughout the midwest provide an additional habitat type of importance." Other studies have shown that California quail, bobwhite, mourning doves, prairie chickens, and antelope are benefited by the additional watering places provided by ponds. A study of the wildlife values of 91 ponds in Missouri revealed that every one of the pond areas was used by some species of game or furbearer (Greenwell, 1948, 1952). A total of 90 species of birds and more than 10 species of mammals were recorded in pond areas. Cottontail rabbits were found at 85 percent of the ponds, doves at 65 percent, muskrats at 63 percent, raccoon at 59 percent, and bobwhite quail at 55 percent. Twenty percent of the farmers questioned believed that a new quail covey headquarters had been established by the building of the pond. It was concluded that: "High level of use by many species indicated impressive wildlife values for farm ponds, but attention to pond location, cover development, and protection from livestock can bring greater values."

Without question the man-made pond has become a reasonably permanent part of our landscape. The number of them now in use totals well over one and a half million and they serve many purposes, utilitarian, recreational and esthetic. Farm and ranch ponds have become a factor of great importance in the welfare of waterfowl, upland game, furbearers and other forms of wildlife. Their development as fish ponds is only one of the opportunities that they offer in wildlife management.

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FARM POND INVESTIGATIONS IN ALABAMA

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Work was begun on pond management at the Alabama Polytechnic Institute in 1934 because of the fact that in most areas of Alabama streams furnished relatively little fishing due to erosion and silting and there were very few natural lakes. Mill ponds and some fish ponds had been constructed as early as colonial times, and there were approximately 700 private ponds in Alabama in 1934. Up to the time this project was started, however, no information was available to those pond owners as to how ponds should be constructed, what kinds and numbers of fish to use in stocking, how to control pond weeds, or how to increase production. As a result, the typical pond of that period was one built upon a rather large stream, subject to heavy influxes of flood water, usually filled with pond weeds from bank to bank—or perpetually muddy from silt brought in by the streams, and yielding average yearly catches of between 5 and 25 pounds of fish per acre per year.

Beginning with an experimental plant of 21 ponds at Auburn, Alabama, in 1934, the facilities were expanded year by year until at present they include 142 experimental ponds, a total of 152 acres of water, operated by the Farm Ponds Project. During this period, these experimental ponds were supplemented by investigations conducted in approximately 1000 private ponds scattered throughout the state to include a wider variety of environmental conditions. In addition, the author has had the invaluable privilege and experience, in cooperation with the U. S. Soil Conservation Service, the U. S. Fish and Wildlife Service, and various State Fish and Game Departments, of seining ponds and examining the fish populations in 29 of the 48 states, located in New England, the Midwest, the Pacific States, the Southwest and the Southeast.

The research in Alabama has dealt with methods of pond construction for fish production, species and combinations suitable for ponds, methods of stocking, methods of pond weed control, mosquito control, fertilizers and fertilization, supplemental feeding, harvest by fishing and trapping, minnow and bait production, and related subjects.

Climatic Conditions in Alabama

In central Alabama, average dates of the first and last killing frosts are November 10 and March 20. At Auburn, Alabama, the water temperatures of the experimental ponds range from 39° to 55° F. between November 15 and February 15. The average of the top and bottom water temperatures in a 9-foot deep pond was approximately 66° F. in April, rising to 82° in August and returning to 66° in October.

Pond Construction for Fish Production

Where a pond is built principally for fish production, it must have certain

features to make efficient management possible. These were found to include an adequate and clean water supply, protection from excessive overflow or flood waters, deepened pond edges to facilitate weed control, an overflow slot or spillway of sufficient width to insure overflow leaving the pond in sufficiently shallow depths to prevent escape of fish, and a drain pipe and valve to facilitate drainage of the pond and removal of the fish if necessary.

The details of pond construction developed at this Station are given by Lawrence (1949). Assistance in planning and locating ponds is given in Alabama by the Extension Service of the Alabama Polytechnic Institute and the U. S. Soil Conservation Service. As a result, the great majority of the 8,000 ponds constructed in recent years meet the above requirements for good ponds.

SPECIES AND COMBINATIONS FOR FARM PONDS

The following are the species that have been or are in various stages of testing for suitability in pond culture at Auburn:

Redeye bass—*Micropterus coosae* Hubbs
Largemouth bass—*M. salmoides* (Lac.)
Smallmouth bass—*M. dolomieu* Lac.
Chain pickerel—*Esox niger* Le S.
White crappie—*Pomoxis annularis* Raf.
Black crappie—*P. nigro-maculatus* (Le S.)
Warmouth—*Chaenobryttus coronarius* (B.)
Bluegill—*Lepomis macrochirus* Raf.
Shellcracker—*L. microlophus* Gunther
Green sunfish—*L. cyanellus* Raf.
Red breast—*L. auritus* L.
Hybrid *L. machrochirus* X *L. cyanellus*
Hybrid *L. macrochirus* X *L. microlophus*
Round flier—*Centrarchus macropterus* Lac.
Yellow bullhead—*Ameiurus natalis* (Le S.)
Speckled bullhead—*A. nebulosus marmoratus* (Le S.)
Channel catfish—*Ictalurus lacustris* (W.)
Blue catfish—*I. furcatus* (Le S.)
Flathead catfish—*Pilodictis olivaris* (Raf.)
Buffalo—*Megastomatobus cyprinella* (Val.)
Ictiobus bubalus (Raf.)
Carp—*Cyprinis carpio* L.
Goldfish—*Carassius auratus* (L.)
Gizzard shad—*Dorosoma cepedianum* (Le S.)
Threadfin shad—*Signalosa petenensis* (Gunther)
Chub sucker—*Erimyzon sucetta oblongus* (G.)
Fathead—*Pimephales promelas* Raf.
Golden shiner—*Notemigonus crysoleucas* (M.)
Gambusia—*Gambusia affinis* (B. & G.)

A more or less routine procedure is followed in testing these species for pond culture. When first brought in for testing, they are isolated, usually for one year, to determine if they will spawn in ponds without special manipulation and also to prevent the introduction of parasites and diseases into the experimental area. If they fail to reproduce under ordinary pond conditions, they are considered of possible value for commercial production and are run in experiments to see what production can be obtained by fertilization and by supplemental feeding. If they reproduce under ordinary pond conditions, they are considered of possible value both for stocking in farm ponds and as possible commercial species. They are usually placed next in 1-and 2-year experiments to determine the production that may be obtained both alone and in combination with other species. They are then placed in 3- to 7-year fishing experiments to see what they contribute to the catch and to see if they are capable of maintaining themselves adequately in the population. It thus requires a minimum of 3 to 5 years merely to determine that a species is of little or no value and from

5 years upward to determine how promising species may be used.

The principal combination recommended as a result of these experiments is one of the bluegill and largemouth bass (Swingle and Smith, 1940, 1947; Smith and Swingle, 1943). This combination is used throughout the Southeast and widely throughout most of the United States. It cannot, however, be used in ponds so small that they support inadequate numbers of bass to insure reproduction, or ponds where summer temperatures of the surface water remain below 80° F., or in brackish water ponds, or in waters carrying heavy loads of suspended silt (Swingle, 1949).

Stocking methods for the bluegill-bass combination were found to be dependent upon the weight of fish which a pond could support. Where the capacity to produce is known, methods of calculating the numbers of each species required to produce balanced populations were developed (Swingle, 1950). This procedure required the determination of the productive capacity of ponds in various sections of each state. This was done in Alabama, and unfertilized ponds were found to be supporting 40 to 200 pounds of fish per acre. No one method of stocking could be devised that would give good results in ponds with such wide variation in productivity. Because of this and also because of the necessity for weed control in farm ponds, all pond owners in Alabama were advised to fertilize their ponds. Where ponds were properly fertilized, weeds were controlled, and the productivities of the ponds were raised and made sufficiently uniform to allow one stocking rate to be used successfully. The rate used for fertilized ponds is 1000 bluegills plus 100 largemouth bass per acre. Experiments on rates of stocking (Swingle, 1951) and experiments on the hook-and-line catch with various rates of stocking indicate that the rate of stocking largemouth bass in such ponds could be varied from 100 to 150 per acre and the corresponding rates for bluegills from 750 to 1500 per acre. The highest average catch per acre resulted from stocking 1500 bluegills plus 100 bass; larger poundage of fish resulted from stocking 1000 bluegills plus 100 bass.

Other combinations of species for farm ponds have also been developed (Swingle and Smith, 1947; Swingle, 1949). For the Southeast, probably the best one for fertilized ponds is 1000 bluegills plus 500 shellcrackers (redears) plus 100 largemouth bass per acre. This combination is widely used in Alabama and elsewhere. The shellcracker is an excellent supplemental species, growing up to 50 percent faster than the bluegill. Speckled bullhead catfish and the white and black crappie may also be used as supplemental pond species, but are less desirable.

BALANCED POPULATIONS AND THE CORRECTION OF UNBALANCE

Balance is that interrelationship within fish populations resulting in successive yearly crops of harvestable fish, satisfactory in amount when the basic fertilities of the bodies of water are considered. These interrelationships are adequately discussed elsewhere (Swingle, 1950).

Many new ponds, regardless of the method of stocking, do not achieve a satisfactory balance. They may produce good fishing for the first season and then fail—or they may never produce satis-

factory fishing. The principal causes of failure, where satisfactory stocking rates were used, have been investigated and those of most common occurrence will be discussed:

Competition with wild fishes already present in the pond before the hatchery fish are stocked is the most common cause of pond failure. This is especially harmful when water is impounded in a new pond during the warm summer months, thus allowing stream fish to reproduce before frost. Two measures can be taken to eliminate this cause of unbalance. First, no water should be impounded until after the first frost; this eliminates most of the difficulty. Second, the wild fishes should be eliminated by poisoning with rotenone the small stream flowing into the pond.

Thoughtless stocking of the new pond with adult fishes by the pond owner or helpful friends before the hatchery fish arrive is another extremely common cause of trouble. The stocking of adult crappie is especially harmful, as this almost always results in an overcrowded population of crappie and necessitates complete poisoning and restocking.

Heavy mortality among the hatchery fishes after they are stocked in new ponds is probably the next most common cause of unbalance. This is sometimes due to poor handling of these fishes, to too long a time in transit from hatchery to pond, to stocking a new pond which does not contain enough water or which fails to fill at the expected time, and to a variety of other causes.

Removal of bass by fishing before they have spawned in the pond for the first time has ruined a large number of farm ponds. In one set of experiments at Auburn, Alabama, 8 out of 8 ponds became unbalanced as a result of opening them to public fishing before bass reproduction had occurred. No fishing should be done in a new pond until one year after the bass have been stocked and after they have reproduced for the first time in the pond.

There are a variety of other causes of unbalance that cannot be discussed here. These, however, make it essential that all new ponds be checked at the beginning of the second summer to determine if balance has been achieved. A method of determining balance called pond analysis, has been developed for this purpose and is described elsewhere (Swingle, 1945).

This method is widely used for the purpose of determining the cause of unbalance and poor fishing. When examined during the second summer, the proper corrective measures can be promptly applied to the new pond to bring it into satisfactory production. In Alabama, the Extension Service and the Fish and Game Division of the State Department of Conservation employ technicians who perform this service for pond owners. In most other Southeastern States this service is available from State Fish and Game Departments, the Soil Conservation Service, and the U. S. Fish and Wildlife Service. In Alabama, an attempt is being made to check each pond during the second summer after stocking. This is resulting in a much higher percentage of productive ponds and is probably the most important service that can be made available to pond owners.

FERTILIZATION

Results of experiments with fertilization of ponds and the problems involved are summarized elsewhere (Swingle, 1947). The results indicated that fertilizers varying from approximately a 6-9-2 to a 12-9-2 should be satisfactory for pond use. In Alabama the following mixture to approximate an 8-8-4, using available commercial grades of fertilizer, is commonly used per acre per application:

100 pounds 6-8-4
5 pounds ammonium nitrate or 10 pounds nitrate of soda.

In this state, the best results are obtained by making three applications about February 1, February 15, and March 1; these are followed by an application every 3 to 6 weeks until frost. The actual number of applications is varied to maintain a plankton growth of such density that visibility is from 12 to 18 inches into the water. The total amount used is thus adjusted to supplement natural fertility. As few as 6 applications per year may be sufficient in rich land areas and as many as 13 to 14 required in infertile areas.

Since fertilization controls underwater pond weeds, reduces or prevents mosquito production, increases fish production, increases the catch of fish, and makes possible the use of one stocking rate, it is essential to good pond management in the Southeast. In Alabama, the yearly catch in unfertilized ponds varies from 5 to 40 pounds of fish per acre, with an average of 15 pounds per acre per year. The yearly catch in fertilized ponds varies from 150 to 300 pounds, with an average approaching 200 pounds per acre per year. If, therefore, only interest on the cost of construction of a pond is calculated at 5 percent on $500, the cost of fish from fertilized and unfertilized ponds may be estimated as follows:

Treatment	*Cost per acre* Interest on Investment	Cost Fertilizer	Catch, pounds per acre	Cost per pound fish caught
Unfertilized	$25.00	0.0	15	$1.66
Fertilized	$25.00	$25.00	200	$0.25

It is evident that it is not an economical practice to operate such ponds on an unfertilized basis.

WEED CONTROL

Weeds must be kept under control in farm ponds if largemouth bass are expected to control the bluegill population and establish a desirable balance. Fertilization and the deepening of pond edges during construction are largely relied upon for underwater weed control in the Southeast. Reports published elsewhere (Smith and Swingle, 1942; Swingle and Smith, 1947) summarize the use of fertilizer for weed control.

Emergent and marginal weeds were controlled in the past by periodic cutting (Smith and Swingle, 1941). However, a spray of 0.5 percent 2, 4-D ester dissolved in diesel oil has proven effective for the control of these weeds at substantially less cost. Two to three applications of this spray has given

acceptable control for a 1-year period. These sprays are at present used by relatively few pond owners in the Southeast; they depend principally upon fertilization, proper pond construction, and grazing of the pond edges for weed control.

PRODUCTION AND FISHING

Numerous experiments have been conducted to determine the total pounds of fish produced with and without fertilization, with supplemental feeding and with various species and combinations of species. In brief, the production in unfertilized waters at Auburn varied from 90 to 200 pounds fish per acre and with fertilization from 300 to 600 pounds per acre where a bluegill-bass combination was used. When plankton-utilizing species, such as gizzard shad, were included in the above combination, production in excess of 1000 pounds per acre has been achieved by fertilization.

Supplemental feeding appears from preliminary experiments at Auburn to promise further increases in productivity. The relatively inefficient bluegill-bass combination has yielded 800 to 900 pounds fish per acre in ponds receiving fertilization plus supplemental feeding, and, with species such as goldfish, production in excess of 2000 pounds per acre has been achieved. Much more work remains to be done upon supplemental feeds, feeding rates and their relationship to water temperatures, population balance, and related factors before supplemental feeding can be recommended for farm ponds.

Work is still in progress upon species combinations that will more effectively utilize the food available in ponds and maintain a high catch per acre over a long period of years. The following are typical average results of fishing experiments with various combinations in fertilized ponds. In these experiments the ponds were subjected to sufficiently intense fishing to harvest the available crop.

Judged from the standpoint of the average yearly catch in pounds per acre, the use of largemouth bass alone was an inefficient method of stocking and did not use efficiently the food available for fish production. Of the other methods listed, the simplest combination giving relatively efficient results was that of bluegill plus largemouth bass.

Balanced ponds containing the bass-bluegill combination have continued to give good fishing for up to 7 years in experimental ponds, and, so far as records are available up to 14 years in private ponds—where fish kills did not occur, pond weeds were controlled, and fertility was kept high by the use of inorganic fertilization. There appear to be certain cyclic changes affecting the annual catch in all fish populations

Stocking Largemouth bass and other species Number per acre	Average annual catch Pounds per acre	Years in each Experiment	Fish recovered on draining Pounds per acre
100 bass	42.2	4	32.9
1500 green sunfish + 100 bass	74.9	2	91.1
1500 shellcrackers + 150 bass	188.6	3	161.1
750 shellcrackers + 750 bluegills + 150 bass	214.5	3	197.2
1500 bluegills + 150 bass	239.4	3	371.3
1500 bluegills + 25 white crappie + 150 bass	282.2	3	301.7

which need intensive study over long periods of time. A knowledge of how to control these changes will aid in maintaining high production.

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POND MANAGEMENT IN ILLINOIS

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Adequate rainfall and tight subsoils over much of Illinois insure that small artificial impoundments are practical and relatively inexpensive as a water supply for domestic stock, orchard spraying, fire protection, and aquatic recreation. In the southern part of the state, small ponds sometimes lie near the crowns of hills with little land above to supply surface water to them. Larger and more useful ponds are built throughout the state by damming small natural water courses at lower levels. On these, "rule of thumb" engineering generally holds, that a pond should need only from 10 to 25 acres of drainage basin for each acre of pond surface. Pond sites which have relatively larger drainage basins may prove expensive because of the need for elaborate spillway structures.

No accurate count of the ponds scattered over the 102 counties of Illinois has been made, although fish management biologists of the State Department of Conservation are now engaged in making such an inventory. Their records show as many as 800 ponds in one county; a few counties may contain more, but most of the

counties contain a smaller number. Even in the flat lands of east-central Illinois, where suitable sites are relatively scarce, a surprisingly large number of ponds have been constructed.

New ponds are stocked by the Department of Conservation after they have been inspected by state fish management biologists, or by the U. S. Fish and Wildlife Service. Old ponds are renovated by draining or by chemical treatment to kill their undesirable fish populations and then are restocked.

The largemouth bass (*Micropterus salmoides*)-bluegill (*Lepomis machrochirus*) combination is most often used in stocking new or renovated ponds. Stocking is done in such a way as to allow the bass to become dominant immediately; otherwise the bluegills rapidly overpopulate the water, become stunted, and curtail the success of bass reproduction. The inability of bass to control the expansion of bluegill populations is believed to be related to two facts: (1) bass do not become sexually mature in Illinois until 2 years of age, while bluegills mature and spawn at one year (James, 1946); (2) nearly all impoundments rather quickly develop populations of native crayfish, which are selected by the bass as food in preference to bluegills. Even if a pond is stocked initially with a dominant population of bass, bluegill populations may expand excessively and fishing may become poor within 6 to 10 years.

Stocking rates of 50 to 100 fingerling bass per surface acre have been generally successful in ponds of one to 25 acres. When this range of numbers is used, the bass grow to one-half pound or more in weight (there is no legal length limit on bass in Illinois) in 12 to 24 months; in this time the total weight of the population may approach the carrying capacity of the water for this species (between 25 and 125 pounds per acre). An equal number of fingerling bluegills may be stocked with the bass fingerlings or at any time later. If other species are stocked with, or instead of, bluegills, the total number of all of these companion fishes is not to be more than 100 per acre.

In ponds of from 5 to 25 acres, it is often more practical to stock with from 1 to 3 sexually mature bass per acre than with fingerlings. These fish are not sexed, but if one or several pairs produce a successful spawn, adequate numbers of young are produced to populate the water. After the bass spawn has been observed, other companion species may be introduced, either as fingerlings or adults. In either case, the numbers should be held within 100 per acre.

For pond owners who are primarily interested in bass fishing, considerable evidence is available from Illinois ponds that any of our native black bass—largemouth, spotted (*Micropterus punctulatus*), or small-mouth (*M. dolomieu*)—will do well in ponds by themselves. Stomach analyses of bass from several of these ponds indicate the importance of crayfish in the diet of these fish. Surprisingly enough the smallmouth is able to reproduce very successfully in warm, mud-bottomed ponds if it does not have to compete with largemouth, crappies (*Pomoxis* spp.), sunfish (*Lepomis* spp.) or bullheads (*Ameiurus* spp.). In fact, in one pond where 20 smallmouth fingerlings and 60 spotted bass

fingerlings were stocked 5 years ago, about 90 per cent of the bass now caught are smallmouths.

Other combinations of fish being tested in Illinois ponds are:

largemouth bass—warmouth (*Chaenobryttus coronarius*)
largemouth bass—redear sunfish (*Lepomis microlophus*)
largemouth bass — bluegill — warmouth — black bullhead (*Ameiurus melas*)
largemouth bass — bluegill — warmouth — channel catfish (*Ictalurus lacustris*)
largemouth bass—short-nosed gar (*Lepidosteus platostomus*)
largemouth bass—bluegill—short-nosed gar
largemouth bass—bluegill—dogfish (*Amia calva*)

Neither the warmouth nor the redear has shown any tendency to produce excessive populations when stocked with largemouth. Neither of these fish is as desirable as the bluegill for fly rod angling. Other combinations have not been tested long enough for passing judgment.

The use of fertilizers is not recommended for Illinois ponds for two reasons: (1) Experiments which have been conducted over a period of 5 years (Hansen & Bennett, MS) indicate that, when the fish are cropped by hook-and-line at average fishing pressures, the small additional yield resulting from periodic applications of inorganic fertilizers will not pay for the cost of the fertilizers. (2) The periodic application of fertilizers often creates nuisance algae problems for which there seems to be no satisfactory solution.

Rooted aquatic plants are more commonly a nuisance in ponds than are floating algae, and sodium arsenite is rather widely used in the control of submerged forms. Emergent vegetation is controlled by the use of "ammate" or 2, 4-D in special carrying agents. Fertilizers are not used in the control of submerged rooted aquatics because of the danger of creating eruptions of nuisance algae.

Poisoning and draining censuses indicate that Illinois ponds support fish populations which vary between 71 and 1,145 pounds per acre, depending upon the natural fertility of the pond drainage basin, the age of the pond, and the kinds of fish present. Expressed in terms of pounds of fish of a single species such as the bluegill, the range of natural fertility might vary from 75 or 100 to 500 or 600 pounds per acre. When fish populations of two or more species in a pond are allowed to expand to approach the carrying capacity of the water for fish, the total poundage supported by the water is not equal to the sum of the poundages that this pond would support of each species alone, but some poundage below this sum. For example, a pond that will support 50 pounds per acre of a pure bass population and 200 pounds per acre of a pure bluegill population, may support a maximum of only 220 pounds of fish when the two species are combined. Although these two species are not strong competitors for the same foods, each may curtail the expansion of the population of the other. As is suggested in the discussion of stocking, bluegills are more effective in controlling bass than are bass in controlling bluegills.

Complete creel censuses on any great number of ponds are difficult to obtain, and partial creel censuses often leave much to be desired, when one is inter-

ested in accurate yield statistics. Occasionally one may find fishing club waters that are supervised by a conscientious caretaker who may operate a continuous creel census from a single point of ingress and egress. Such a situation made possible the study of overfishing in Onized Lake (Bennett, 1945). A few clubs keep records of fish yields purely from the standpoint of interest of members, but these records rarely include accurate statistics on hours spent in fishing. Farmer owners of ponds may record accurately their own fishing activities but often fail to obtain records from friends or neighbors who are given free entrance to their ponds. These difficulties in collecting dependable statistics through pond owners, and the impracticability of hiring full time men for creel census work on relatively small bodies of water, necessarily limit the opportunities for obtaining dependable data on pond yields. Such dependable data as are on hand for a small number of Illinois ponds, indicate that fishing pressures on most ponds range from a minimum of a few man-hours of fishing per acre per season to a maximum of around 300, with an average fishing pressure of less than 100 man-hours per acre per season. Fishing club ponds usually receive more intensive use, and fishing pressures on these waters may average 200 to 250 man-hours per acre per season. It is probably rare for waters to be fished to the extent of 500 or more man-hours per acre except in unusual situations such as that of Onized Lake and on some park lagoons of large cities.

No recorded hook-and-line yields of bass and pan fishes have approached that of Onized Lake of 350 pounds per acre for a single season, taken with a fishing pressure of 1,415 man-hours per acre. The angling crop from most good fishing waters is below 50 pounds per acre per season, although some fishing club waters in the more fertile sections of Illinois may produce 100 or more pounds per acre. Such crops are unusual, and evidence indicates that angling is probably the most inefficient of man's methods of taking fish. For this reason, the Illinois Fish Code currently in force allows owners of small artificial impoundments to use licensed seines, wing nets, and wire-mesh traps in their ponds, to augment the crop of fish that may be taken on hook and line.

Many factors other than the available crop of fish and the fishing pressure influence the rate of catch and the actual hook-and-line yield of fish. This was shown at Ridge Lake where, during 8 fishing seasons, annual yields of bass varied from 10.9 to 30.0 pounds per acre and of bluegills from 6.2 to 46.0 pounds per acre (Bennett, 1951, p. 233, 235). In each year the available crop of fish was known and fishing records were complete.

Not only do yields vary from year to year in a single pond, but several ponds of about the same size and age, located in the same soil type and originally stocked with the same kinds and numbers of fish, may show great differences in catch rates and annual yields. This is true, regardless of whether the ponds are fertilized or unfertilized (Hansen & Bennett, MS). Therefore, in the prediction of fish yields only very broad general statements can be made.

In pond fish populations involving two or several species of warm-water fishes, the largemouth bass is an essential

component because of its suitability to the pond environment, its high value in angling, and its ability to slow the expansion of populations of companion species. The maintenance of strong bass populations is fundamental to the production of good angling in ponds. Bass eggs and fry are very vulnerable to predation by other species of fish (particularly other centrarchids), and any measures that will reduce the population pressure of these companion species will almost invariably increase the survival of young bass (Bennett, 1951, p. 236). The numerical size of populations of companion species may be reduced through partial or complete draining of a pond, partial poisoning, and in small ponds by the use of small mesh seines or electric fish shocking devices.

In larger ponds, the draining technique (Bennett, 1951, p. 237) is preferable to all other methods of population control because it allows an appraisal of an entire fish population, and permits the operator to adjust the numbers and size range of any species within that population. Its main drawback lies in the problem of the finding of a suitable holding basin for the temporary storage of fish to be returned to the drained pond as soon as sufficient water is reimpounded.

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MANAGEMENT OF INDIANA PONDS FOR FISHING

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At present there are probably more than 7,500 farm ponds in Indiana that are suitable for fish life. However, either because of improper stocking with fish, inadequate fishing, poor construction of the pond itself, improper fencing from livestock, or any combination of those and/or other factors concerned with proper management, perhaps fewer than half of those ponds provide satisfactory angling on a sustained basis. Of the factors listed, improper stocking and inadequate fishing are the ones that occur most frequently. If properly stocked and adequately fished almost any suitable pond will provide continuously good fishing.

The topography and the value of the land for agricultural purposes in Indiana are such that the majority of the farm ponds are located in the southern third of the state. In that region, where there is a large driftless area, the soils and topography are almost ideally suited for pond construction. The remaining ponds are largely confined to the central third of the state where the relatively flat topography and high agricultural capability of the land limit the use of much of the surface area for impounding runoff waters. The soils of the northern third of the state are generally not suited to the construction of ponds (Krumholz, 1950a).

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In Indiana, and probably elsewhere as well, the correct solution to initial stocking policies for small ponds lies largely in the selection of the proper kind or kinds of fish. That selection should be based on rather exhaustive studies in which many different kinds of fish are tested. The ideal combination of fishes in such an artificially established population is one in which all species will constantly contribute to the angler's catch. Also, the species should preferably not be in direct competition for food. None of the species selected should possess such a relatively high reproductive potential that they will eventually become so numerous as to crowd out the others.

To furnish good fishing on a sustained basis, a pond in Indiana should be at least six or seven feet deep and have an area of at least half an acre. A very small pond is frequently more difficult to manage for fishing than a large one because of the limitations imposed by the requirements of the fish themselves. Although small and shallow ponds have provided good fishing at times, such ponds are usually not capable of maintaining satisfactory populations of more than one kind of fish. In using combinations of more than one kind of fish, such as a predator and a non-predator, enough space must be provided so that the larger predatory species can produce a sufficiently large population to maintain itself. For instance, an unusually good catch of bass from a very small pond at a critical time in the life

cycle could so decimate the population that it could not recover. The chances are, in such an instance, that the other species would overpopulate the pond and a stunted population would result. Single species of fish, if not too prolific, seem to be best suited to small ponds in Indiana.

Personnel of the Indiana Lake and Stream Survey have been actively engaged in research on farm ponds since 1942 when Ricker (1948) made a preliminary investigation of the use of hybrid sunfish for stocking purposes. Later on, the program was expanded, and since 1944 more than 250 ponds, stocked in various ways, have been studied (Krumholz, 1950a, 1950b, 1950c). Most of that work was confined to ponds in southern Indiana.

The kinds of fish that have been used in stocking experiments, either individually or in combination with others, were: largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), spotted bass (*M. punctulatus*), bluegill (*Lepomis machrochirus*), redear sunfish (*L. microlophus*), bluegill x redear sunfish hybrids, rock bass (*Ambloplites rupestris*), yellow perch (*Perca flavescens*), and channel catfish (*Ictalurus lacustris punctatus*). In addition, such species as the white crappie (*Pomoxis annularis*), black crappie (*P. nigro-maculatus*), green sunfish (*Lepomis cyanellus*), longear sunfish (*L. megalotis*), black bullhead (*Ameirus melas*), and yellow bullhead (*A. natalis*), although not stocked by the Lake and Stream Survey, have been observed in ponds in various combinations with the other species mentioned above. The species combinations used in our plantings were:

Redear sunfish, bluegills, and largemouth bass;

Redear sunfish, bluegills, and smallmouth bass;

Redear sunfish, bluegills, and spotted bass;

Redear sunfish with either largemouth or spotted bass;

Bluegills with either largemouth or spotted bass;

Rock bass, bluegills, and largemouth bass;

Yellow perch, bluegills, and largemouth bass.

The following species were observed after having been stocked alone: largemouth bass, bluegills, redear sunfish, rock bass, black bullheads, and channel catfish.

Also, we observed the following combinations stocked by other agencies:

Bluegills with largemouth bass;

Bluegills, black and/or white crappies, and largemouth bass;

Bluegills, black and/or yellow bullheads, and largemouth bass;

Bluegills, green sunfish, black bullheads, and largemouth bass.

All plantings were made with fingerling fish in the late fall of the year.

In 1946, ponds were stocked with fingerling bass together with bluegills and/or redear sunfish on an experimental basis. In some ponds largemouth bass were used; in others, spotted bass; and in others, smallmouth bass; the first two species seem to do about equally well in ponds in Indiana, whereas the smallmouth bass is apparently not well adapted for life in such impounded waters. The numbers of bass planted ranged from 500 down to 100 fingerlings per acre; the numbers of bluegills and/or redear sunfish from

one-tenth to twice the number of bass. In addition, the fish populations in ponds that had been stocked by other agencies at a rate of 1,500 bluegill fingerlings and 100 bass fingerlings per acre were observed. All populations were sampled with a one-quarter-inch mesh bag seine fifty feet long at yearly intervals for the first three years after stocking. Some ponds stocked by other agencies were sampled as late as eight years after stocking.

Of this series of combinations, the best suited for ponds in Indiana was the redear sunfish together with either the largemouth or spotted bass. Each of those three species is desirable to the angler and all are highly regarded as food. The redear sunfish is recommended over the bluegill because it is not so prolific as the bluegill and has a more restricted spawning period. The combination of bass and bluegills in Indiana usually results in an overpopulation of bluegills within a very few years after stocking. The apparent reasons for such an overpopulation are the prolificness of the bluegill and the inadequacy of the bass as a predator.

The actual numbers of fingerlings of either species planted did not seem to have any direct bearing on the future success of the population unless one or the other was introduced in overwhelmingly large numbers. So far as ponds in Indiana are concerned, it seems necessary to introduce only enough individuals of each species concerned to get the population established.

Combinations of fish using largemouth bass and bluegills together with some other predatory species as the rock bass, black crappie, or white crappie yielded populations that were more satisfactory than those containing only bass and bluegills. The crappies or rock bass are sufficiently predatory to assist the bass in keeping the bluegill population from running rampant. However, unless the ponds have a considerable extent of water more than eight feet deep rock bass or crappies do not thrive in Indiana.

The use of single species of fish in stocking small ponds has yielded information of value in those areas where the topography of the land precludes construction of ponds larger than half an acre. There, the hybrid sunfish (bluegill x redear sunfish) has yielded good fishing. However, because of the generally unbalanced sex ratio among the hybrids it is usually necessary to restock the pond at intervals of three or four years. Rock bass, when planted alone, are fairly satisfactory as pond fish. They reach desirable sizes in a short period of time and are able to maintain an adequate population.

Channel catfish, when stocked alone in a pond, grow rapidly. Usually they will not spawn in ponds unless some spawning facilities are provided. Thus, the size of the population can largely be controlled by placing the spawning devices in the pond only when necessary.

The following numbers and kinds of fish are recommended for the initial stocking of ponds in Indiana:

100 redear sunfish fingerlings and 100 largemouth bass or spotted bass fingerlings;
200 rock bass fingerlings alone;
200 channel catfish alone;
500 hybrid sunfish alone.

All of these recommendations are made on a per-acre basis, but if the pond is smaller than half an acre, it is better to

put in enough fish to supply a half acre of water.

There are several species of fish that should not be stocked in ponds in Indiana. They are: the green sunfish, the black bullhead, the longear sunfish, or any other of the small sunfishes. Such species as the carp (*Cyprinus carpio*), buffalofishes (*Ictiobus* spp.) and the gizzard shad (*Dorosoma cepedianum*) should also be avoided.

The natural fertility of a body of water, and consequently its ability to support a fish population, is directly dependent upon the fertility of the watershed. Because of the relatively high fertility of the soil, there is generally no need to fertilize ponds in Indiana in an effort to better the fishing. Not only is the application of fertilizers to ponds in Indiana unjustifiable, but such procedures may have serious drawbacks. Perhaps the most serious drawback is the imminent danger of marked oxygen depletion of the pond water during the hot summer months. Such an oxygen depletion can virtually wipe out a fish population overnight. Another frequent occurrence following the application of fertilizers in ponds in Indiana is the formation of very large mats of filamentous algae. At times the mats may become so extensive as to completely cover the pond surface.

Unfertilized ponds in Indiana will support at least 250 pounds and up to as much as 600 pounds of fish per acre, depending on the fertility of the soil in which the pond is located. The average is about 400 pounds. Ordinarily, at least half of the total weight of any fish population can be harvested annually without having any detrimental effect on the ability of the population to maintain itself. In fact, the experimental evidence at hand indicates that such a harvest is highly desirable. Thus, most ponds in Indiana are capable of giving sustained annual yields of upwards of 150 pounds per acre. Even though such yields are possible, they are rarely, if ever, achieved because of inadequate fishing.

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FARM FISH POND RESEARCH IN IOWA[1]

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A recent survey of County Agricultural Extension Directors indicated that there are about 3400 farm fish ponds in Iowa (Moorman, 1952). The number of ponds is increasing each year and the survey indicated that 758 ponds were stocked with fish in 1951, most of them for the first time. The fish for these ponds came from the State Conservation Commission, the Fish and Wildlife Service and from various private sources. The Iowa State Conservation Commission, which stocked 143 ponds in 1951, limits its stocking program to ponds over one-half acre in surface area and at least eight feet deep. Furthermore, the owner must agree to permit "reasonable use" of the pond for public fishing without charge and must protect the pond from livestock and erosion.

Most of Iowa's farm ponds are in the southern half of the state where other fishing waters are scarce. The management recommended by the Soil Conservation Service and the State Conservation Commission generally follows that developed at the Auburn (Alabama) Experiment Station. Largemouth black bass (*Micropterus salmoides*) and bluegills (*Lepomis machrochirus*) are usually the only species stocked. Comparatively few of the ponds are artificially fertilized and it is believed that fertilization is not as essential to good management in Iowa as it is in some other areas where soils are less fertile. Since the dangers of oxygen depletion during the five months of ice cover are increased by fertilization, caution is recommended in the application of fertilizers.

The Iowa Cooperative Fisheries Research Unit has been carrying on studies of farm fish ponds since 1946, with observations and test netting on about 175 ponds to date. One of the principal phases of the research has been an investigation of the marking and recovery technique of estimating fish populations. The ponds are seined with a 50 to 70 foot drag seine and the captured fish are fin-clipped and returned to the pond, until about one-third of the fish taken in a seine haul have already been marked. In ponds under one-half acre, two to three good seine hauls will usually capture sufficient fish. Further seining is then delayed until at least the next day to permit the fish to become less disturbed and more normally distributed. The population is then estimated by seining three or four times and determining the proportion of the fish in the catch which are marked.[1]

$$P = \frac{cn}{m}$$

where P = population estimate
c = catch
n = number of marked fish in pond
and m = number of marked fish recaptured

[1] Project 37, Iowa Cooperative Fisheries Research Unit sponsored by the Iowa State Conservation Commission and the Industrial Science Research Institute of Iowa State College, with the cooperation of the Fish and Wildlife Service, U. S. Department of Interior.

Population estimates on 30 ponds made in this fashion seemed to be quite reasonable and the standard errors of estimate (as determined by the formula given by Schumacher and Eschmeyer, 1943) were frequently as low as 5 to 10% of the estimate (Fredin, 1950). Satisfactory estimates of the adult largemouth bass population could be secured in only a few ponds because of the difficulty of capturing bass in the seine. The estimates of bluegills, crappies (*Pomoxis* spp.) and black bullheads (*Ameiurus melas*) usually appeared to be within expected limits, however. It was possible to treat five ponds with rotenone to verify the estimates. It was recognized that complete collection of fish after rotenone treatment could not be secured in ponds where the bottom was not visible, but an estimate of the percentage collected was made from the collection of the marked fish. The percentages of the marked fish which were collected in the various ponds were as follows: Johnson pond, crappies 14%, bluegills 38%, bullheads 80%, and golden shiners 91%; Jensma pond, bluegills 65%, bullheads 71%, and largemouth bass 94%; Blom pond, bullheads 91%; and McCormick pond, bullheads 86% and goldfish 90%. The percentage collected differed so much between species even in the same pond that it was impossible to get a satisfactory estimate of the species composition from rotenone treatment unless the percentage collected was determined for each species (Carlander and Lewis, 1948). The percentage of fish which come to the surface and can be collected apparently differs with the concentration of rotenone used (Moorman and Ruhr, 1951).

A comparison of population estimates from the marking and recovery technique and those from rotenone treatment showed general agreement, but there were a few wide discrepancies. In the following cases the population as estimated from the rotenone treatment was well within the 95% confidence limits of the estimate from marking and recovery: bluegills in two ponds, and one estimate each of white crappie (*Pomoxis annularis*), golden shiner (*Notemigonus crysoleucas*), largemouth bass, and black bullhead. In three ponds the bullhead estimates and an estimate of the goldfish (*Carassius auratus*) population were considerable less than the numbers collected after rotenone treatment.

It is believed that the failure to secure satisfactory estimates by the marking and recovery technique in some situations was due to a tendency for the fish caught and marked to be more easily recaptured than the fish which escaped the nets the first time. An experiment in trapping bluegills revealed a tendency for the same individuals to enter the trap time after time (Lawrence, 1951). Estimates of the population based upon fish originally caught in traps, fin-clipped and released, and then recaptured in the same or another trap failed to level off but showed a gradual decline. Estimates made at the same time based upon fish originally caught in seines, fin-clipped and released, and then recaptured in traps, stabilized after nine days of trapping. It appears that the selectivity of seining and of trapping are not the same, so that more reliable estimates may be secured when fish for marking are captured by one meth-

od and then recaptured by another.

The Swingle method of determining population balance from the reproductive success of bass and bluegills, as demonstrated with a minnow seine, was used in classifying many of the ponds. In 111 ponds sampled from 1948 to 1950, 56.8% were judged to be "in balance", 15.3% were overpopulated with bluegills, 6.3% with bass, 19.8% with other species, and 1.8% had no fish at all.

Since the Swingle method of determining population balance has been criticized (Bennett, 1948, 1950, Krumholz, 1951), the data determined from marking and recovery estimates were compared with the condition of balance as determined with a minnow seine (Table 1). Swingle (1950) reports that in balanced populations the ratios of forage to carnivorous fishes (F/C ratio) ranged from 1 to 10. In the Iowa investigations 5 of 7 F/C ratios for the balanced ponds were in this range. In the 13 ponds classed as overcrowded with bluegills or with "other species", 8 had ratios of over 10.0 indicating a shortage of predators. Perhaps even more significant is the fact that 5 of the 10 ponds classed as in balance or overcrowded with bass had over half of the total weight of the fish in catchable sizes, whereas in only 2 of the 13 ponds overcrowded with bluegills or other species was the abundance of catchable-sized fish as high.

One fish population not included in the above may be mentioned although the results may not be comparable since the pond was in a gravel pit. This 4.5 acre pond was treated with rotenone to remove a large population of buffalo (*Ictiobus cyprinella*). Trapping and seining failed to capture enough fish for a marking and recovery estimate, but after the rotenone treatment, 1,235 pounds of fish per acre were collected (Carlander, 1952). Largemouth bass, bluegills, and yellow bass (*Morone interrupta*) had spawned successfully and no other species had done so. The populations would therefore be classified as "in balance" by the Swingle minnow seining technique, and yet less than 7% of the poundage was suitable as game or pan fish. If the large carp, buffalo, and carpsuckers (*Carpiodes* spp.) are disregarded, the forage fish (bluegill, bullhead, small crappie and small yellow

TABLE 1.—COMPARISON OF POUNDS PER ACRE, RATIOS OF FORAGE TO CARNIVOROUS FISH, AND PERCENTAGES OF TOTAL POUNDAGE WHICH WERE OF CATCHABLE SIZE IN PONDS IN DIFFERENT CONDITION AS CLASSIFIED BY SWINGLE'S METHOD.

Ponds	Pounds per acre			Ratio of pounds of forage to carnivorous fish			Percentage which was of catchable size****		
	No.	Mean	Range	No.	Mean	Range	No.	Mean	Range
"in balance"	7	127	66–221	7	6*	3–11	7	50	15–94
overcrowded with bluegills	7	148	28–228	5	13**	3–27	7	30	2–82
bass	3	172	100–305	3	6	2– 8	3	59	36–71
other species	6	208	54–370	3	8***	4–11	6	22	0–61

* One pond with a ratio of 332 not included.
** Two ponds with no carnivorous fish not included.
*** Three ponds with no carnivorous fish not included.
**** Bass over 10 inches, bluegills and green sunfish over 6 inches, crappies over 8 inches, and bullheads over 7 inches.

bass) to carnivorous fish (largemouth bass and channel catfish) ratio was only 0.5. Some minnows were not collected but their abundance was not believed to be great enough to change the F/C ratio appreciably.

Some of the ponds classified by the Swingle method as being overcrowded with bluegills have been stocked with large fingerling and subadult bass from nearby ponds. The success of these experimental manipulations of the population cannot be evaluated as yet, but the bass have at least become established and have reproduced in some of the ponds.

Several of the Iowa ponds have been found to be thermally and chemically stratified with only the top 3 to 5 feet holding sufficient dissolved oxygen for fish life during the summer months. It is believed that this reduction in living space after the spawning season has contributed to slow growth and stunting of the fish (Sprugel, 1952). Despite the fact that the deeper waters contain no dissolved oxygen and rather high concentrations of carbon dioxide, the fish apparently enter them for short periods of time. On several occasions traps 5 to 8 feet below the oxygenated water have contained bluegills. Even when the traps were lifted after only two hours, most of the fish which entered the traps and were thus detained in the deoxygenated waters were dead.

Although most of the Iowa ponds are in areas where other fishing sites are scarce, very few of the ponds are adequately harvested at present. The annual yield in the vast majority of the ponds is probably less than 20 pounds per acre, even in ponds with good fish populations. More fishing and control of stunted populations are probably the measures most needed for better fishing.

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KENTUCKY'S FARM FISH POND PROGRAM

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Kentucky has approximately 110,000 farm ponds, at least three-fourths of which are capable of producing good fishing. Since 1936 the Agricultural Extension Department of Kentucky reports the construction of 66,252 ponds. The Department further reports that the construction rate annually has remained constant at an average of 4800 in the last few years.

Demands for the stocking of new ponds and the creation of good fishing in old ponds are increasing at a rapid pace. At present the Division of Game and Fish receives annually 3,000 requests for stocking.

Success in establishing good fishing in unstocked ponds is directly related to methods, rates, species and sizes stocked. Swingle and Smith (1947) found bluegill (*Lepomis machrochirus* Rafinesque) and bass (*Micropterus salmoides* Lacepede) the most suitable species for stocking ponds in the southeastern states. During seven years many species, various rates, and different size fish have been planted in ponds in Kentucky.

Some 250 ponds have been investigated for determination of balance and classification as fish ponds. Those which were offering good fishing and seemed to have approached a balance were inspected at least once and usually twice each year thereafter. In addition to personal inspection, many reports were made by conservation officers, sportsmen's clubs and fishermen regarding fishing success in ponds stocked.

Rates and Methods of Stocking

Only the bass-bluegill combination has been used successfully in Kentucky ponds. Success, defined in this case as excellent fishing which lasts from year to year, has been entirely limited to a stocking rate of 30 adult bluegill to 100 bass fry. Adult bluegill are stocked from October through the following June with bass fry planted in May of the same year.

At the end of the first five months, the growth rate of bass averages from $1\frac{1}{2}$ to 2 inches per month, while the first spawn of bluegill has grown at a rate averaging from $\frac{3}{4}$ to 1 inch per month. Test netting studies indicate that both bass and bluegill spawn heavily early in the first summer after stocking. At this time the bluegill population consists of all sizes and the young bass are in excellent condition.

So consistent are results in ponds stocked by this method, that ponds stocked by this method can be easily recognized by test seining, prior to an examination of stocking records. In early summer a short swirl with a 20-foot minnow seine in the waters' edge reveals bass fingerling, numerous bluegill fry, and a few intermediate sized bluegill. By late summer or fall, bass of the year are not usually taken in the test net. These have advanced to a size which requires more complete seining efforts to demonstrate their presence.

In only one pond has superabundance

of intermediate sized bluegill been found in 7 years' study of ponds stocked at this rate. This one instance is attributed to a complete lack of fishing since the pond was stocked. All other ponds, including those now in their eighth year, are still providing good fishing.

Fishing is an important factor in maintaining balance over a period of years. Some ponds remain unfished although in excellent condition because the pond owner has no knowledge or interest in fishing. This type of owner usually prohibits others from fishing.

The effect that fishing plays on population conditions was noticed while studying seven ponds in one county, all stocked with adult bluegill and bass fry. These ponds average slightly more than 1 acre. Each was studied by test net twice yearly for 6 years. At the end of the first year, both bass and bluegill spawned and all pond owners were advised to begin fishing. By the third summer, pond No. 1 had never been fished, bass had not spawned a second time, and only numerous bluegill fry could be obtained by test net. Use of large seines showed large bass and large bluegill only. There was no apparent change in the population until late 1951 when a superabundance of intermediate bluegill was found.

Until 1951 pond No. 4 had been fished regularly. In 1949 the pond owner recorded 45 pounds of bass taken. A few others probably were taken for some fishermen failed to post their catch. No record was kept on bluegill. In 1951 a test conducted for 15 minutes by fly fishing yielded 6 bluegill averaging 7 inches and 3 bass averaging 12 inches. The test net showed the population to be in excellent balance with an ideal bluegill range.

Pond Nos. 2, 3, 5, 6 and 7, which had experienced various degrees in fishing intensity, all showed bass reproduction and a range of bluegill sizes. However, the best size range of bluegill was found in those ponds which had been fished the most.

Study of these 7 ponds indicates that a total lack of fishing allows the pond's carrying capacity to be expressed in large fish only. In the fourth or fifth year, whether by reason of death of the original bass or by a lack of predator effectiveness (Holloway, 1951), such ponds will become overpopulated with bluegill.

Experiments have been conducted using 100, 150, 200, 300 and 500 adult bluegill in ponds in conjunction with 100 bass fry. All, by the end of the second year, were crowded with 3-inch bluegill.

Other experiments conducted with 30 adult bluegill stocked prior to the middle of September and 100 bass fingerling stocked the following July have resulted in overcrowded bluegill populations. The bass do not mature and spawn in the second summer in these ponds while bluegill spawn at least once in the first year stocked.

Stocking of ponds with 100 bass fingerling in July or August and with 30 adult bluegill the following spring resulted in balanced populations in the third summer. Nothing is gained in using this method. Had the ponds been stocked the following spring with bass fry and adult bluegill, fishing could have started in the same length of time.

A number of ponds have been stocked with 100 bass fry in May and 30 adult

bluegill the following fall. Bass and bluegill spawn heavily the next summer as evidenced by checking 15 ponds so stocked. Such ponds have always resulted in balanced populations in the third summer when fished after the first bass spawning period. These ponds are now in their sixth year and are still excellent fish ponds.

The addition of white crappie (*Pomoxis annularis* Rafinesque) in small numbers to ponds stocked with adult bluegill and bass fry resulted in a stunted population of crappie by the fourth year.

Good bluegill and crappie fishing in ponds can be had only by creating a heavy bass population. Then as the crappie gradually disappear, the pond may be balanced by heavy fishing with no creel and size limit on bass. Adult bluegill should be added at this time to assist in creating a balanced condition between bass and bluegill. In bodies of water which are being fished regularly, 300 adult bluegill per acre have been used successfully in overstocked bass ponds.

Such corrective stocking is obviously necessary only when ponds cannot be drained or treated chemically. City reservoirs often fall in this class due to rulings of some public health departments.

At present there seems to be some hope that black crappie (*Pomoxis nigromaculatus* LeSueur) may be used successfully in deep, heavily fished ponds stocked with bluegill. Ponds should apparently be not less than 5 acres in size. In no case, however, has fishing success in such ponds equalled that of those ponds stocked only with bass and bluegill.

Since 1949 practically all applications received have been stocked with bluegill fingerling and bass fry. This size bluegill was stocked either in late fall or early spring followed by bass fry plantings in May. The unfertilized rates of 50 bass and 500 bluegill, 60 bass and 500 bluegill, and 80 bass and 500 bluegill have consistently produced poor fishing in all sections of Kentucky. Each rate has been tried hundreds of times in all sections of the State. There is not one pond so stocked which is known to have maintained a balanced condition through its third summer. All become overcrowded with bluegill, necessitating corrective measures.

In only five ponds from this entire group has reproduction been found by July of the second summer. Test netting at this time showed bluegill reproduction to be light with intermediates of that species being too numerous.

These ponds may be brought into balance by partial elimination of the bluegill population and the addition of 100 small fingerling bass per acre followed by heavy bluegill fishing. Such fish management practices become too involved for those interested in creating fishing in the 3,000 new ponds annually and thousands of others already in need of renovation.

To date only 492 fertilized ponds have been stocked in Kentucky using fingerling bluegill. All of these ponds were stocked with 1000 fingerling bluegill from November through April and 100 bass fry the following May.

A few ponds which were correctly stocked and correctly fertilized have been followed for as much as four years. By the fourth year adult bluegill were

reduced in size and bass fingerlings were in poor condition. Heavy fishing might have prohibited such an occurrence.

POPULATION MEASUREMENTS

The only means of directly measuring fish populations is by draining the pond and weighing all size groups of species found. Swingle (1950) found the desirable weight ratio of bass to bluegill to be 1 to 3. Stocking rates thus may be determined when a pond's carrying capacity is known. Some of the factors which modify carrying capacity in unfertilized ponds are the soil, variations in annual rainfall, area of the pond's watershed, wind action, and the number of livestock using the pond or watershed from month to month or year to year. In balanced ponds properly or fully fertilized at all times, there is little variation in carrying capacity.

Little is to be gained from studying unbalanced populations, other than to learn which species is in need of control. Weights of unbalanced populations cannot be interpreted as the pond's carrying capacity for balanced populations of bass and bluegill. Total poundages of fish produced per acre have ranged in Kentucky from 200 to 1000 pounds in unfertilized waters.

FERTILIZATION

Little can be added to the many papers dealing with fertilization of farm fish ponds. Amounts, periods of applications and types of fertilizer best suited are well known to fish pond technicians. However, there are still problems which must be answered before fertilization is advocated on a statewide basis.

Apparently there are at least three factors favoring properly fertilized fish ponds. First, the harvest of more pounds of fish through an increased carrying capacity has been well established. Second, troublesome weed problems are eliminated. Third, the establishment of a more or less uniform carrying capacity for all ponds in a large area makes it possible to stock these ponds at one rate using bass fry and bluegill fingerling.

There are certain adverse factors which must be considered before fertilization is recommended generally. First, in Kentucky at least, too many ponds fail to respond to the usual recommendations. In such cases complete water chemistry studies must be made and detailed care given the pond in supplying elements needed. Eight ponds have failed to respond to all attempts of fertilization over a period of seven years. This may happen even though another pond close by develops and maintains a bloom when almost any type of commercial fertilizer which contains nitrogen, phosphorus and potassium is added at more or less regular intervals. Second, fertilization is seldom needed, except as a weed control measure, for rarely is a pond fished enough. This may be explained in part by the presence of an unusually large number of ponds, lakes and streams. Third, few farmers are interested enough in fishing to follow a particular pond's required schedule of fertilization or to furnish sufficient fertilizer when it may be needed on other crops.

DISCUSSION

As yet, the stocking of 100 bass fry and 30 adult bluegill per acre in fertilized or unfertilized waters in Kentucky is

the only rate and method of stocking found satisfactory. If fishing is practiced, lasting balance may be expected between the two species. Success of the method is little affected by small errors in estimating water acreage to be stocked or by the introduction of a few other species (crappie excepted) by the farmer who sometimes feels it necessary to practice supplementary stocking.

Careful interpretation of minnow seining results indicates whether desirable ratios between bass and bluegill have been secured. Needs for corrective measures or increased fishing pressure on either species seem to be indicated to a delicate degree. In the presence of other species, especially crappie or catfish, mistakes may be made in poorly conducted netting studies.

Pond size, depth, degree of slope, area of watershed, aquatic plants, water temperatures, wind action, water chemistry and rainfall are all factors affecting the success of any farm fish pond program.

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FARM POND MANAGEMENT IN MICHIGAN

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Michigan has about 11,000 named lakes and many other smaller bodies of water, 28 river systems, and has on its borders four of the Great Lakes, so that in general the need for impoundments is not as pressing as in some areas. Despite the abundance of natural fishing waters they are not randomly distributed. This factor, plus the many advantages that come from private ownership, has resulted in the building of a considerable number of farm ponds in the state. The exact number of impoundments is not known but is relatively low compared with many southern states.

The problems of farm pond management in Michigan are quite unlike those of the South because of differences in climate, soil, natural waters, and desires of the fishermen. In 1946 a cooperative project was established by Michigan State College and the Michigan Institute for Fisheries Research to investigate management procedures applicable to ponds of this region. Two reports (Ball and Tait, 1952; Ford and Ball, 1951) have resulted from this work and others will be forthcoming.

As many as 36 ponds, varying in size from 0.04 acre to 3.5 acres, were in

* In cooperation with Michigan Institute for Fisheries Research.

use during the pond fish investigation. Some were used several times during the five year study period. The ponds represented many types of habitats, varying from rich to poor in organic bottom deposits, and ranging from 120 to 180 parts per million in total hardness. The water source for a few of the ponds used early in the work was from a river impoundment. The others were fed directly or indirectly from large springs. Water was replaced as lost and was also added to maintain oxygen under the ice cover when needed. No water was allowed to overflow at the spillway during the fish's growing season. Water temperatures were near or above 70° F. from about May 20 to September 1. Ice cover lasted as long as five months.

STOCKING METHODS

We have used population combinations that included the largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), bluegill (*Lepomis machrochirus*), bullheads (*Ameiurus nebulosus* and *A. melas*), redear sunfish (*Lepomis microlophus*), hybrid sunfish (*L. microlophus* x *L. gibbosus*), and several species of minnows. The majority of the work, however, was with largemouth bass and bluegill combinations.

Wherever possible the ponds were studied in pairs chosen for physical and chemical similarities. From various combinations of bass and bluegills came the strong evidence that stocking in this region must be with adult bluegills and fingerling bass. Bass and bluegills grow much more slowly in this area where the growing season is limited to a maximum of six months, and as a result they do not reach maturity until their third summer. It is evident then that in ponds stocked with fingerling bass and fingerling bluegills there will be two growing seasons before the bluegills reach maturity in which there will be no small bluegills as food for the bass. It is generally assumed that the success of a bass-bluegill stocking combination is dependent upon young bluegills serving as forage for the bass.

Where mature bluegills produce young the first year, our experiments showed that fingerling bass stocked with adult bluegills, weighed twice as much at the end of the second year and three times as much at the end of the third year as bass stocked at the same time with fingerling bluegills. We believe that this slow maturing of the forage species is a major factor in the need for a method of stocking ponds different from that applicable to southern waters. There is strong evidence that in Michigan's hardwater ponds, with the accompanying dense beds of submerged aquatic plants, predator bass are not able to crop bluegills sufficiently to prevent their overproduction and stunting. We are recommending that new ponds be stocked with 100 bass fingerlings and 10 adult bluegills per acre.

Combinations of largemouth bass and golden shiners (*Notemigonus crysoleucas*) have been found to be satisfactory in weedy ponds here. Where the primary interest of the pond owner is sport fishing and large fish are preferred, this combination is superior to the bass-bluegill combination in that bass reach a catchable size in shorter time (Ball and Ford, unpub.). It appears that adequate brood stocks escape predation and young golden shiners are produced

at rates which allow bass to continue to make good growth.

Recently we have brought the redear sunfish to central Michigan where it appears to be able to withstand winter conditions and to reproduce in the ponds. It appears to be considerably less prolific than the bluegill and shows no signs of becoming overly abundant when stocked in combination with largemouth bass. As in the case of the bluegill, the redear sunfish apparently does not spawn every year, and water temperature appears to be the limiting factor. The redear sunfish is primarily a bottom feeder and very seldom rises to a surface bait, thus is less of a sport fish than the bluegill. It does, however, reach a larger size in our ponds.

PRODUCTION OF FISH

A group of ponds selected as representative of the different management procedures being tested were drained at the end of the second and the third summer and the composition of the population recorded each time. At the time of the first draining the standing crop ranged between 193 and 721 pounds per acre, averaging 313 pounds. Of the total weight of the fish, approximately one-third of the bluegills were over 5.0 inches and one-third of the bass over 7.2 inches total length. For this study these were considered as edible-size fish. The total weight of fish recorded at the end of the third year did not vary greatly from that of the preceding year. The production data probably represent a higher production of fish than would be obtained in the average farm pond in Michigan since the test waters were rich in organic matter.

FERTILIZATION

The problems of fertilization which arise from differences of water hardness, bottom soils, vegetation types, and other factors are made even more complex by the variable climatic conditions of Michigan.

The production of fish varied greatly among the several ponds. Fish in unfertilized ponds in some instances showed better growth and/or greater production than in fertilized ponds. In comparable ponds, fertilization produced an average of 163 pounds of edible-size fish per acre, while in unfertilized ponds an average of 77 pounds per acre was grown. All sizes of fish averaged 365 pounds per acre in fertilized ponds as compared with 260 pounds per acre in untreated ponds. In Michigan fertilization apparently increases the production of both fish-food organisms (Patriarche and Ball, 1949) and of fish (Ball and Tait, 1952), but other considerations make the use of added nutrients of questionable value.

The problem of adequately harvesting the fish crops from a pond is an unsolved one. It is quite evident that adequate harvesting seldom is accomplished in farm ponds. For this reason we have suggested (Ford and Ball, 1951) that, in addition to the use of the ponds for recreational fishing, fish from them be harvested as any other crop and processed and frozen for future needs. Unless this is done there seems little economic justification for additions of fertilizers to increase the standing crop of fish.

The ponds used in our experimental work were such that water could be run through them during the period of

ice cover whenever there was a threat of oxygen depletion. The possibility of winterkill is ever present in our shallow bodies of water (Greenbank, 1945) regardless of size when snow and ice cover them for an extended period of time. This threat is much greater in waters rich in organic materials, and is increased by the addition of fertilizers. Because of these considerations we do not recommend the addition of nutrient materials to our farm ponds unless a proper harvest is undertaken and water can be supplied during the winter.

AQUATIC PLANTS

Aquatic plants pose a major problem in the management of Michigan ponds. With few exceptions luxuriant growths of rooted aquatics occur. These interfere with harvesting of fish, make fishing and swimming difficult or impossible, and afford shelter to young fish that might otherwise be available to the bass.

Fertilizer applied to these weedy ponds produced, without exception, filamentous algae, not plankton algae. This agrees with the findings of Hasler and Jones (1949) and of Surber (1945) in the hard water ponds of West Virginia. If allowed to continue throughout the summer, the algal mat would considerably reduce rooted aquatic plants, and while present would render the pond worthless for other purposes.

Complete elimination of the rooted aquatic plants appears impossible even by the continued application of fertilizer. The filamentous algae resulting from fertilization can be killed by copper sulfate, but the rooted plants grow with renewed vigor rather than a plankton algae bloom appearing.

The results of an extensive research program (Levardsen, 1951) failed to produce a practical method of controlling the higher aquatic plants in the hard water of Michigan lakes and ponds, and until a method is devised that is inexpensive and can be safely recommended to the average pond owner the management of fish populations must take into account the problems associated with dense plant beds.

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SUMMARY OF SELECTED POND STUDIES IN MISSOURI

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An estimated 59,600 ponds were built in Missouri from 1937 to 1949 and they have been constructed at the rate of approximately 10,000 per year since. More than 18,000 have been stocked by the Conservation Commission in the past 10 years. Ponds in Missouri average between one-third and one-half acre in surface area. Only those which meet certain specifications are approved for stocking with largemouth bass and bluegill at the rate of 100 bass and 1000 bluegill per acre of water.

The large numbers of ponds which have been built and stocked and the amount of recreation which they provide justify a program of investigation to improve methods of management. The pond investigation program conducted by the Conservation Commission consists of six projects. These include studies of water fertilization for fish production, stocking ratios of largemouth bass and bluegill, other stocking combinations, effects of reversing the stocking order of bass and bluegill, vegetation control, and yield under heavy fishing pressure. The fishery research programs of the Conservation Commission and the Missouri Cooperative Wildlife Research Unit are closely integrated and in many respects the two agencies function as one. The Research Unit program, which is largely more basic, fortifies the more direct program of the Conservation Commission. Included here are preliminary comments on several of the projects which are being carried on by these agencies.

[1] Chief Biologist, Fisheries Section, Missouri Conservation Commission.

[2] Contribution from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation, and University of Missouri cooperating.

Phytoplankton

Qualitative and quantitative phytoplankton data gathered at two-week intervals for 23 months from three adjacent ponds are furnished by Proctor (unpublished). His findings emphasized: (1) a marked similarity existed between the phytoplankton of these ponds and Danish ponds; (2) a fertilized pond was more productive of phytoplankton than were unfertilized ponds; (3) flagellated phytoplankters were most abundant; (4) diatoms were relatively unimportant; (5) Cyanophyta occurred only in fertilized ponds; (6) in the second year algae blooms of the same species reappeared at the same season only in the fertilized pond; (7) individuality of ponds was emphasized. "Of the ninety-three species found in the survey more than one-half were restricted to individual ponds. Less than one-sixth were common to all three of the ponds."

Thermal and chemical characteristics

Ponds 6 – 8 feet deep show definite thermal and chemical stratification.

They differ most from northern glacial lakes in the pronounced warming of the bottom water during the summer and in the frequent absence of a clearly defined epilimnion, thermocline and hypolimnion. A representative vertical temperature series from June 19, 1945, at one-foot intervals of depth beginning at the surface is as follows: 72, 71, 69, 68, 68, 64, 62, 61, 60 and 60° F.

Nitrogen and Phosphorus

Nitrogen and phosphorus content of two fertilized and four unfertilized ponds is reported by Zeller (unpublished) for an eight-month period. Nitrate and nitrite nitrogen did not vary significantly from pond to pond, but appeared to be affected by the watershed vegetation and by aquatic plants present in the ponds. Phosphate phosphorus availability and plankton abundance showed general correlation during the summer.

Vertical distribution of these nutrients was related to thermal stratification. Phosphate phosphorus was the most distinct in this respect; bottom concentrations were two to ten times as great as surface values.

Water Fertility

As an approach to the study of water fertilization for producing fish, experimental ponds are being used in three soil areas characterized by poor, intermediate and high agricultural crop production. In these ponds the quality and amount of fertilizer used are being determined by chemical analyses of the water. Controls are being maintained throughout the study. The quantity of dissolved plant nutrients is being followed closely by chemical analyses during the summer growing season to observe changes which may occur. The distribution of various fertilizer materials added to the water is being studied. At the termination of the study the total standing crop of fish will be ascertained to measure the effects of the various fertilization procedures upon fish production.

Aquatic Plant Control

Experiments have been conducted to test the effectiveness of recently developed herbicides for controlling certain species of aquatic vegetation. Twelve of the experiments are discussed here. At this time others are not sufficiently conclusive either to merit a favorable recommendation or to consider them unsatisfactory. Control methods are being sought also for submerged and other emergent plants.

Arrowhead (*Sagittaria latifolia* Willd.) was killed with ammonium sulfamate (Ammate), Esteron 245 and Esteron Brush Killer. Esteron 245 was applied in water mixture consisting of 1 ounce of the herbicide and one-half ounce of washing detergent (Dreft) per gallon of water. The washing detergent was used as a wetting agent. The Ammate spray solution was mixed similarly, but in the amount of one pound per gallon of water. Esteron Brush Killer was applied in an oil mixture consisting of one ounce of Esteron Brush Killer per gallon of diesel oil. These mixtures used on five plots in two ponds were applied with a back-pack sprayer.

Control of this species of arrowhead with each of these herbicides is considered satisfactory. However, Esteron 245 in a water mixture is the cheaper control for small applications, and

proved to be faster acting than Ammate or Esteron Brush Killer.

Good-rite A.M.C.C. (allyl mixed chlorophenyl carbamate)* was used experimentally for controlling lesser duckweed (*Lemna minor* L.) on two ponds. The herbicide was mixed with diesel oil at the rate of 1 ounce per gallon and sprayed directly on lesser duckweed. One hundred fifty to 200 gallons of this spray mixture per acre gave effective control on a single floating layer of this plant. However, a concentration of 2 ounces of A.M.C.C. per gallon of diesel oil was required for effective control where these plants were concentrated in a thicker layer. On the strength of the experiment A.M.C.C. is considered satisfactory for controlling lesser duckweed.

Five plots of water primrose (*Jussiaea diffusa* Forsk) in two ponds were subjected to experiments in which Esteron 245 and Esteron Brush Killer were used. Both herbicides were used in water mixtures with a detergent, and both were used in diesel oil. Concentrations of one ounce per gallon were used in both water and oil mixtures. The washing detergent, Dreft, was used as a wetting agent at the rate of one-half ounce per gallon in the water mixtures. The two herbicides were about equally effective both in oil and water mixtures, but the oil mixture is preferred because its action is more rapid. The water mixture is cheaper.

In further experiments Esteron 245 and Esteron Brush Killer were applied on water willow (*Dianthera americana* L.). Both were used in like concentrations in a water mixture with a wetting agent as described above. On the strength of observations made on two experimental plots in a single pond, both herbicides are considered satisfactory for controlling water willow.

Growth of bluegill and bass in fertilized and unfertilized ponds

In a study of the effect of water fertilization upon the growth rate of fishes (Burress, unpublished), four ponds were stocked in 1947 with young of the year at the rate of 100 largemouth bass and 1,000 bluegill per acre. Ponds 1 (0.45 acres) and 2 (0.34 acres) were fertilized semi-monthly at an accumulative annual rate of 1,000 pounds of 4-12-4 inorganic commercial fertilizer. Ponds 4 and 6, having surface areas of 0.27 and 0.75 acres respectively, were not fertilized. Vegetation was present in all ponds to varying degrees. The growth rate of both bass and bluegill brood stock during the first four years was significantly higher in the fertilized ponds.

The average length and weight of the 1947 year class of bass were consistently greater for each of the four years through which their growth was followed (Table 1). In November, 1950, four years after they were stocked, the original bass in fertilized ponds averaged 15.8 inches in length and weighed 38.5 ounces. The average length for those in the unfertilized ponds was 11.8 inches and the average weight 12.4 ounces.

The differences in the length and weight of the 1947 year class bluegill in the two sets of ponds were not as pronounced as they were for bass, but the bluegill followed a similar trend in

* Available only from the Goodrich Chemical Company in 1951.

TABLE 1.—THE AVERAGE GROWTH IN TOTAL LENGTH (INCHES) ATTAINED BY THE 1947 YEAR CLASS OF BLUEGILL AND LARGEMOUTH BASS FOR 1948, 1949 AND 1950 IN FERTILIZED AND UNFERTILIZED PONDS. SAMPLE SIZE IS SHOWN IN PARENTHESES.

Pond Number	Largemouth Bass 1948	1949	1950	Bluegill 1948	1949	1950
Fertilized						
1	10.4 (13)	14.5 (24)	15.8 (8)	5.5 (50)	5.8 (135)	6.3 (20)
2	11.0 (19)	14.3 (17)	15.9 (3)	6.0 (61)	6.9 (52)	7.5 (37)
Unfertilized						
4	8.8 (9)	10.4 (13)	11.1 (6)	4.8 (27)	5.7 (17)	6.0 (18)
6	9.6 (21)	11.4 (11)	12.1 (12)	5.1 (84)	5.6 (223)	6.1 (5)

growth. In November, 1950 (Table 1), the length of the initial bluegill stock in the fertilized ponds averaged 7.1 inches and the weight 4.2 ounces. Bluegill in the unfertilized ponds averaged 6.0 inches in length and weighed 2.2 ounces.

Pond 1 was the only pond in which the bass failed to spawn. The slower growth of bluegill in this pond, when compared with growth in pond 2, is probably related to decreased predation.

Growth details of year classes 1948 and 1949 do not contradict these findings, but variations in growth which did appear were associated with complexities of population development. Scale resorption which appeared with increased age in both bluegill and bass occurred in greater proportion in unfertilized ponds. Details of population development and related scale resorption will be presented in a separate publication.

Yield from a Public Use Area

Eight impoundments were opened for fishing for the first time in 1950 on a state owned public use area located within 30 miles of St. Louis. During the initial 79-day fishing season these waters were fished by 15,030 anglers. In 1951, thirteen additional impoundments were opened to the public for a fishing season of 100 days. The 21 bodies of water were fished by 17,108 anglers. Four of these impoundments were small lakes having surface areas of 12.0, 15.8, 18.0 and 20.0 acres. The remainder varied in surface area from 2.0 to 5.7 acres. A record of the fishes creeled and fishing pressure in these waters is maintained through a special permit system. Tables 2 and 3 show the number and weight of each species creeled and the fishing pressure in hours per acre for seven of these impoundments which were opened for fishing in 1950 and again in 1951. All of these waters were stocked with largemouth bass, bluegill and channel catfish. Black crappie which appear in the creel in lakes 3 and 4 for both years were not stocked intentionally. In Table 2 it will be seen that black crappie were reported in lakes 5, 6, 7 and 8. It is almost certain that this occurred through error in the reporting system. Presumably fishermen who caught the 15 crappie recorded for these ponds did not report having taken them in lake 3 or 4. Through the failure of some anglers to cooperate by reporting their creel, the recorded hook and line harvest for both years is thought to be somewhat less than the quantity creeled.

Lake 10 (3.5 acres) was drained at the end of the initial 79-day fishing season

TABLE 2.—THE APPROXIMATE NUMBER AND WEIGHT IN POUNDS AND THE WEIGHT PER ACRE OF FISHES REMOVED BY ANGLERS FROM SEVEN IMPOUNDMENTS LOCATED ON THE AUGUST A. BUSCH MEMORIAL WILDLIFE AREA IN 1950, AND THE FISHING EFFORT FOR EACH LAKE EXPRESSED IN MAN HOURS PER ACRE

Lake No.	Area Acres	Largemouth Bass Number	Largemouth Bass Weight	Bluegill Number	Bluegill Weight	Channel Catfish Number	Channel Catfish Weight	Black Crappie Number	Black Crappie Weight	Total Number	Total Weight	Weight per acre	Man Hours per acre
3	3.2	70	80.5	980	264.6	44	132.0	138	45.5	1232	522.6	163.3	2222.9
4	2.0	91	39.1	823	214.0	12	48.0	862	284.5	1788	585.6	292.8	3511.4
5	3.4	160	219.2	656	183.7	1	4.0			817	406.9	119.7	1961.6
6	18.0	685	493.2	5831	1515.1	19	11.4			6535	2020.7	112.3	1090.8
7	12.0	372	200.9	2971	772.5	18	13.5			3361	986.8	82.2	690.6
8	15.8	444	226.4	2417	628.4	58	44.7			2919	899.52	56.9	697.4
9	2.0	161	154.6	1115	267.6	10	7.7			1286	429.9	214.9	1376.6

TABLE 3.—THE APPROXIMATE NUMBER AND WEIGHT IN POUNDS AND THE WEIGHT PER ACRE OF FISHES REMOVED BY ANGLERS FROM SEVEN IMPOUNDMENTS LOCATED ON THE AUGUST A. BUSCH MEMORIAL WILDLIFE AREA IN 1951, AND THE FISHING EFFORT FOR EACH LAKE EXPRESSED IN MAN HOURS PER ACRE

Lake No.	Area Acres	Largemouth Bass Number	Largemouth Bass Weight	Bluegill Number	Bluegill Weight	Channel Catfish Number	Channel Catfish Weight	Black Crappie Number	Black Crappie Weight	Total Number	Total Weight	Weight per acre	Man Hours per acre
3	3.2	99	71.5	898	119.3	9	32.9	95	32.9	1052	256.5	80.2	1493.8
4	2.0	116	33.7	1219	181.5	6	21.8	334	94.4	1675	331.3	165.5	2196.0
5	3.4	55	48.1	285	48.5			8	1.8	348	98.4	28.9	346.2
6	18.0	691	233.7	5374	978.9	16	26.9	2	.1	6082	1239.6	68.9	634.1
7	12.0	167	60.1	986	160.8	31	40.6	4	.6	1188	261.3	21.8	305.3
8	15.8	237	150.0	1707	303.2	49	65.4	1	.3	1994	591.2	34.6	503.9
9	2.0	23	26.6	165	29.1	4	5.5			192	61.4	30.9	529.5

to determine the standing crop of fish which remained. The total creel from this lake during the first season consisted of 1,247 fish weighing 404.2 pounds; a yield of 115.5 pounds per acre. A complete census revealed that a standing crop of 47,185 fish weighing 729.4 pounds remained in the lake at the close of the fishing season. Among these fishes were 67 usable bass weighing 80.2 pounds, and 728 small bass weighing 75.0 pounds. Remaining also were 160 usable bluegill weighing 42.6 pounds, approximately 46,168 bluegill of small and intermediate sizes having a total weight of 493.8 pounds, and 62 channel catfish weighing 37.7 pounds. This body of water received 3,457.2 man hours of fishing during the 79-day fishing season in 1950.

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RANCH FISH PONDS IN MONTANA [1]

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There are over 40,000 small ranch ponds in Montana. More than three-fourths of these were constructed solely for stock-water purposes and most of the others for either irrigation or the control of erosion. Fewer than 50 are known to have been built specifically for fish. (Brown and Thoreson, 1951). While approximately 700 ponds have been stocked with fish of one species or another, less than 100 are known to have produced any appreciable fishing.

During 1949 and 1950, the Montana Agricultural Experiment Station and the Montana State Fish and Game Department conducted a cooperative investigation of existing Montana ranch ponds to explore their suitability for fish. About 20 ponds scattered over the eastern (plains) part of the state were examined at regular intervals throughout all seasons and inventories were made on a large number of other ponds as time permitted. The data included certain physical, chemical and biological information considered essential to an understanding of fish production.

A summary of the physical-chemical information collected on twelve ponds is given in Table 1. The most striking physical feature is the prevailing low temperature even during the summer period. The water in ponds of this area is generally quite alkaline with the pH as great as 10.0 and total alkalinities (methyl orange) as high as 325 ppm.

While aquatic plants of varied species are present in many ponds, they have not been found detrimental in ponds which were deep enough to insure fish production. In one small pond, mortality of trout was definitely attributed to low dissolved oxygen resulting from duck weed (*Lemna*) which completely covered the surface and which was found in large quantities, decaying on the bottom.

Past records show that the following fish species have been planted in Montana ponds: rainbow trout (*Salmo gairdnerii*), brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), cutthroat trout (*Salmo clarkii lewisii*), bluegills (*Lepomis machrochirus*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigro-maculatus*), yellow perch (*Perca flavescens*), walleye (*Stizostedion vitreum*), northern pike (*Esox lucius*), black bullheads (*Ameiurus melas*), golden shiner (*Notemigonus crysoleucas*), and bluntnose minnow (*Hyborhynchus notatus*).

Recommendations

On the basis of investigations completed, recommendations have been made for both fish pond construction and management. Some of our sugges-

[1] Contribution from Montana State College, Agricultural Experiment Station. Project No. MS844, Paper Number 265, Journal Series.

tions are quite arbitrary since we have little information on many important aspects of the problem. On the other hand, some have a very sound basis. The following are some of the more important recommendations.

TABLE 1.—SOME PHYSICAL AND CHEMICAL DATA OBTAINED FROM MONTANA PONDS

Name of pond and location	Date	Surface					Bottom		
		Water temp.(F.)	D.O. (p.p.m.)	pH	Phth. (p.p.m.)	M.O. (p.p.m.)	Water temp.(F.)	Depth (ft.)	D.O. (p.p.m.)
Johnson	6/ 3/49	58	10.0	7.4	0	160	55	10	5.5
18N R6E	11/17/49	40	14.0	7.0	0	160	—	10	—
S 30	12/26/49	32	12.5	7.9	0	170	38	10	—
	3/31/50	33	14.0	7.9	0	165	38	10	9.0
Tesinsky	6/ 4/49	77	12.0	7.0	0	110	60	9	6.0
18N R5E	11/15/49	37	5.0	8.0	0	120	37	9	5.0
S 24	12/23/49	32	5.0	7.6	0	120	39	7	5.0
	3/31/50	33	10.0	7.2	0	115	40	7	7.0
Irwin	6/ 6/49	70	15.0	8.1	0	140	66	10	6.0
18N R5E	9/28/49	66	6.0	8.1	0	170	—	10	—
S 36	12/29/49	32	5.0	8.2	—	—	—	8	—
	3/30/50	33	14.0	—	0	150	40	10	6.5
Birkland	9/ 3/49	61	8.0	7.4	0	150	60	25	6.5
23N R7E	3/30/50	33	11.5	7.5	0	155	42	17	2.5
S 1									
Nelson	11/15/49	38	7.5	8.3	20	175	38	15	7.0
18N R6E	12/26/49	32	3.5	7.7	0	190	36	10	3.0
S 30	3/31/50	33	12.0	8.0	—	—	36	8	11.0
Baugh	6/10/49	78	7.0	7.7	0	55	74	11	2.0
18N R5E	9/14/49	52	4.0	8.0	5	85	50	10	3.0
S 2	12/28/49	32	2.0	7.2	0	55	38	10	2.0
	4/ 1/50	38	10.0	—	5	60	42	12	3.0
P.R. 95	6/28/49	70	10.0	9.2	35	145	68	14	10.0
28N R29E	11/ 8/49	40	12.0	8.9	0	145	40	12	10.0
S 8									
P.R. 18	6/30/49	60	10.0	8.1	8	100	59	20	8.5
25N R30E	11/ 8/49	42	4.0	8.4	5	140	40	20	4.0
S 33									
P.R. 20	7/ 1/49	65	8.5	7.1	0	75	64	15	8.0
23N R30E	11/ 8/49	41	8.0	7.4	0	80	70	16	5.0
S 1									
Nelson	6/ 4/49	60	12.0	8.0	0	120	57	9	10.5
18N R6E	11/16/49	33	13.5	8.3	10	195	37	8	5.0
S 30	12/23/49	32	8.5	8.0	—	—	38	8	7.0
	3/31/50	42	17.5	—	10	150	—	8	—
Lindsey	7/13/49	80	9.0	8.3	9	325	72	10	6.0
7N R52E	2/15/50	32	10.0	8.0	5	310	35	10	7.0
S 19	4/25/50	42	8.5	8.0	5	315	42	10	7.0
Simms	7/31/49	75	8.0	10.0	40	110	59	15	5.0
36N 3W	11/ 5/49	38	12.0	9.2	20	130	65	12	11.0
S 32	3/29/50	62	8.0	—	20	120	36	10	2.0

Construction—Most Montana ponds have shown extensive bank erosion. Very few have been adequately graded and in some instances dams have been washed out. Almost no ponds have been fenced, resulting in bank trampling by livestock, and high water turbidities. Careful grading and complete fencing is recommended. An outlet adequate to completely drain the pond is considered essential, not only to facilitate pond maintenance, but for the proper management of fish populations.

Depth—Ponds which are supplied by run-off alone should have an actual depth of at least 10 feet for one-fifth of the pond area during the lowest water period. Greater depths are desirable, but are usually not necessary to maintain fish. The presence of ice as thick as 40 inches is not uncommon and the ice cover may persist as long as five months. This makes deep water imperative to provide space and oxygen during this critical period.

Area—The size of ponds is not as important as depth. Ponds as small as one-fourth acre have provided worthwhile fishing for a family, but it is desirable to make them of two or more acres if they are for community use.

Cold water ponds—Since many Montana ponds are more suitable for cold-water than for warm-water fish, it has been suggested that the maximum summer temperature 2 feet below the surface be checked. If temperatures do not exceed 74° F. then the pond is considered to be best managed for cold-water fish. To date, eastern brook trout have proven to be the most ideal fish for cold water ponds in Montana. Rainbow trout are second choice and have shown almost as good results in some instances. Stocking rates for new ponds vary from 200-500 fingerlings (1½ - 3 inches) per surface acre.

The rate at which brook trout grow is illustrated by a study of a plant of advanced fry made in Irwin Pond, Cascade County, on May 1, 1948. A sample of 15 specimens taken on June 9, 1949, averaged 7.4 inches in total length and 2.5 ounces in weight. By September 28 of this same year the average total length was 9.6 and the weight 6.5 ounces and by May 13, 1950, these fish had reached an average length of 10.9 inches and a weight of 7.8 ounces.

Warm-water ponds—For the time being large-mouth bass and bluegills are being recommended for warm-water ponds, although plantings of these species have not been satisfactory except in a very few instances. Plantings in new ponds of 100 bass to 500 bluegills per surface acre is recommended. Past experience has shown a number of cases where rates of 1 bass to 10 bluegills have resulted in large numbers of stunted bluegills.

The writers do not feel that bass and bluegills are generally suited to our so-called warm-water ponds. The growing season is too short and temperatures ordinarily remain too cold for good growth.

The growth rate of largemouth bass and bluegills can be seen in Tables 2 and 3. Bluegills did not reach six inches in total length until their fifth summer and large-mouth bass did not reach ten inches until their fourth summer. These growth rates were rather typical of the ponds studied.

TABLE 2.—GROWTH RATE OF BLUEGILLS (*Lepomis macrochirus*) COLLECTED FROM MONTANA RANCH PONDS

Pond name	Date	No. of fish	Age	Lgth. (in.) when caught	Length at annulus (in.)					
					1	2	3	4	5	6
P.R. 56.....	11/ 8/49	2	0	1.0						
P.R. 56.....	11/ 8/49	1	I	2.3	1.2					
P.R. 137.....	11/ 8/49	4	I	2.9	1.3					
McGlinn	7/10/49	11	III	5.5	1.0	2.4	5.0			
Cochran.....	7/16/49	3	III	6.1	1.1	2.5	5.1			
Cochran.....	7/16/49	13	IV	7.0	1.2	3.3	5.6	6.3		
Baugh.....	6/10/49	3	IV	6.9	1.2	4.8	5.9	6.6		
Cochran.....	7/16/49	2	V	6.5	1.0	3.2	4.9	5.8	6.2	
P.R. 20.....	6/30/49	2	VI	7.8	1.3	3.0	5.0	6.5	6.9	7.6
Weighted average				5.7	1.1	3.0	5.3	6.3	6.6	7.6

Fertilization—While pond fertilization experiments in Montana have been entirely inadequate, the results observed to date do not demonstrate any appreciable benefit from fertilization. Several ponds which were fertilized had either partial or complete winter kills. In view of the long period of ice cover and accompanying critical conditions characteristic of ponds in this region, no fertilization is recommended at this time.

EXPERIMENTS IN PROGRESS

Some attempt has been made in eastern Montana ponds, mostly by hatchery personnel, to test various fish species combinations and ratios. Results from these tests are inconclusive. A rather extensive series of investigations are now underway by the Montana Fish and Game Department. These are aimed to determine both species combinations and ratios for cold as well as warm water ponds. In addition to experimental plantings of brook trout and rainbow trout, cold water ponds are being tested with American grayling (*Thymallus signifer*) and kokanee (*Onchorhynchus nerka kennerlyi*). Warm water ponds are being experimentally stocked with the following species: western sauger (*Stizostedion canadense*), walleye, northern pike, channel catfish (*Ictalurus lacustris punctatus*), largemouth bass, bluegill and black crappie. No results are available as yet on any of these experiments.

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TABLE 3.—RATE OF GROWTH OF LARGEMOUTH BASS (*Micropterus salmoides*) COLLECTED FROM MONTANA RANCH PONDS

Pond name	Date	No. of fish	Age	Lgth. (in.) when caught	Length at annulus (in.)			
					1	2	3	4
Devon	5/31/49	5	II	4.0	1.7	3.5		
Cochran...	7/16/49	1	II	6.0	1.9	4.9		
Baugh.....	6/10/49	10	III	10.6	2.2	7.4	10.4	
Baugh.....	6/10/50	6	IV	10.9	2.2	7.4	10.1	10.8
Weighted average				9.0	2.1	6.4	10.3	10.8

SOME RESULTS OF FARM POND MANAGEMENT STUDIES IN NEW YORK[1]

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The number of farm ponds in New York has increased at a rapid rate during the past few years. According to data obtained from the State Conservationist, U. S. Soil Conservation Service, 3,254 ponds have been constructed. This may be considered a reasonably accurate estimate of the total number in New York since comparatively few have been built without supervision of this agency. The average New York pond is about one-third to one-half acre in area. There is no accurate breakdown of the number stocked with fish. The information herein is based upon observations of over fifty farm ponds in New York since 1949. The discussion of results with trout and warm-water species will be presented separately.

Bass-Bluegill Ponds

The combination of 1000 bluegill fingerlings and 100 largemouth bass fingerlings per surface acre as well as fertilizer recommendations and schedules proposed by the Agricultural Experiment Station of the Alabama Polytechnic Institute have been recommended by the Soil Conservation Service for this area. The average growth rates, reproductive habits, expected weight-ratios, and other relationships between and within species have been described by Swingle (1950) in defining balanced or successful ponds in the Southeast. Few of these criteria are either established or maintained under New York conditions when similar stocking and management practices are followed. The overall results in bass-bluegill ponds have been unpredictable. Some of the reasons for this are presented.

Water temperatures appear to be the primary reasons for the lack of success with the bass-bluegill combination. Close agreement has been found between the temperature limits for bass and bluegill reproduction stated by Swingle (1949) and those obtained in New York. The period when water temperatures in shallow water remain at 80° F. or greater lasts approximately one month in central New York.

Harvestable bass of approximately ten inches and bluegills of six to seven inches may be expected no sooner than two years after stocking (Saila, 1950). Most of these observations were made on initially stocked fish in fertilized ponds. There is some reason to believe that subsequent hatches occurring naturally grow still more slowly due to increased competition.

Successful bluegill reproduction may occur one year after stocking when temperature and food conditions are favorable, but only one hatch per year has been observed. Under no conditions,

[1] The studies upon which this summary is based were supported by three annual grants-in-aid from the New York State Conservation Council.

including the stocking of bass fingerlings after successful bluegill reproduction, have bass spawned successfully until they were two years old. The number of bass available for angling during both the second and third years after stocking is restricted to the originally planted fish. A second planting of bass has been made in some experimental ponds, but no data are available as yet.

Fertilization of ponds according to standard Alabama recommendations generally produces better growth than that in unfertilized ponds, but results of fertilization are unpredictable. New York presents such a variety of soil and water conditions that it would be surprising if a single fertilizer would produce satisfactory results in all ponds.

Variable stocking ratios of bass and bluegills ranging from 2 to 5 to 1 to 10 produced no observable differences in angling success. Seven out of thirteen ponds two or more years old were considered successful using reproduction of both species as the sole criterion of success. The limitations of this method as outlined by Fessler (1950) and Krumholz (1951) are appreciated and apply equally in New York State.

Annual yields of fish by angling in a one-acre pond varied from approximately 50 to 90 pounds for three seasons, but only 6 bass of 10 inches or more were caught during the second and third seasons. Higher yields have been reported by some pond owners.

In general New York ponds stocked according to present recommendations with bass and bluegill have not yielded satisfactory results on a sustained basis. The use of new species combinations or alterations of existing recommendations may offer greater promise. Because there are great differences in the interests of pond owners in a management program, future recommendations should be as simple and foolproof as possible.

TROUT PONDS

A preliminary investigation (Saila, 1950) indicated that trout in New York ponds had possibilities and emphasis in farm pond research at Cornell to date has been largely in this direction. The overall results of the management of farm ponds for trout have been satisfactory if good fishing can be considered indicative of pond success. Problems in management have usually been less complex than in warm water ponds, and successful ponds have been the rule.

The limitations of high temperature have been considered the primary restriction to widespread use of trout in New York ponds. Evidence as summarized by Fry (1951) indicates that 77.5° F. is the lethal temperature to brook trout upon prolonged exposure, but higher values can be tolerated for short periods of time. During the summer of 1951 surface temperatures (approximately six inches) in a pond fed by a small amount of spring seepage remained between 75-79° F. for 24 days with no harmful results. The maximum bottom temperature for this period was 74° F. Although a small permanent water supply is considered optimum, management of ponds fed exclusively by runoff is possible.

Our studies suggest that brook trout are more desirable than the brown or rainbow for New York ponds primarily because they are short-lived and most vulnerable to angling. The prin-

cipal drawback of the rainbow is its spring spawning habit, resulting in poor condition of the fish for spring fishing.

Stocking rates have varied from 150 to 600 fingerlings per surface acre of water. Three hundred is accepted at present as a reasonable figure for most conditions, although it is evident that ponds vary considerably in their carrying capacities. Little difference in survival for a six month period is apparent between spring versus fall fingerling plantings (Table 1).

TABLE 1.—SURVIVAL OF FINGERLING BROOK TROUT IN FARM PONDS—INITIAL STOCKING

Pond Number	Time Stocked	Number Stocked per Acre	Percentage Survival 6 Months
1	Fall	300	86
2	Fall	375	82
4	Spring	350	76
5	Spring	500	90
6	Spring	350	73

Estimates of survival at approximately 6 month intervals for the various ponds have been made with bag seines up to 150 feet long, using the marking and recovery method described by Ricker (1948). Confidence limits for these estimates are narrow because the ratio of marked to unmarked fish is high (approximately 0.5) and the samples large.

Inorganic fertilizers appear to improve the growth of trout as compared to that in unfertilized ponds. Heavy fertilization during summer months definitely increases the marginal nature of many ponds, resulting in oxygen depletion, formation of toxic materials and a heavy summer kill. A maximum amount of 300 pounds of fertilizer per acre per year applied spring and early fall is suggested.

Successful fishing can be obtained within a year after stocking fingerling trout in New York farm ponds. Fall fingerlings of three to five inches reach legal size of seven inches or more by the following spring (April). Two to three inch spring-stocked fingerlings also reach this size by the following April. The observed growth at approximately six-month intervals is described (Table 2). Growth in the three species has been comparable.

Natural reproduction of farm pond trout has not been successful to date. This appears to be a disadvantage, but it assures good control of population numbers if information is available on survival rates of the initial and subsequent plantings. Preliminary data on survival of restocked trout suggest that fall fingerlings are most satisfactory and have survival rates comparable to the initial planting even with predator populations of larger trout present. Therefore, subsequent plantings are recommended to be at the same rate as the initial planting if the pond is subjected to fishing. There is some possibility that eyed eggs may be used for the initial planting (Anonymous, 1951).

Yields of trout up to 90 pounds per acre have been reported, but total production has been estimated at 50 to 100 pounds in experimental ponds. Experience has shown that moderately experienced fishermen can remove a substantial share of the brook trout population during the spring.

The presence of moderate amounts of aquatic vegetation, lack of fertilization or lack of fishing pressure appear to

TABLE 2.—MEAN OBSERVED LENGTHS AND WEIGHTS AT APPROXIMATELY SIX MONTH INTERVALS, AND THE INSTANTANEOUS (OR LOGARITHMIC) RATE* OF GROWTH FOR EACH PERIOD (AS PERCENTAGE PER PERIOD) OF BROOK TROUT (POND NO. 1—INITIAL PLANTING)

Period	Number in Sample	Fork Lgth. (inches)	Wt. Oz.	Instantaneous Growth Rates Fork Lgth.	Wt.
Age 0 Fall.....	25	6.13	1.67	—	—
Age I Spring.....	30	7.77	3.38	24	70
Age I Fall.....	26	9.80	7.80	23	84
Age II Spring.....	15	10.33	7.34	15	-6

* Computed according to methods of Simpson and Roe, 1939, p. 348.

have no disastrous effects upon trout production in farm ponds.

Trout ponds with no permanent source of water supply have experienced varying degrees of summer kill. In ponds of this type it is possible to stock fall fingerlings and harvest a large percentage of the existing population during the following spring. Conditions under ice cover in ponds are in need of further investigations.

Most of the brook trout examined were sexually mature at the end of the second growing season. Since growth decreases and natural mortality increases after maturity, harvesting of the fish should take place prior to this if optimum yields are desired (Table 2).

The stocking of trout in New York farm ponds gives better results than the bass-bluegill combination. The management procedures described, although subject to change as new information is obtained, can be expected to assure reasonable and predictable results.

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POND FISH STUDIES IN SASKATCHEWAN

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Pond fish production in Saskatchewan is still in an early stage of development. During the past 15 years large numbers of small reservoirs have been constructed in the prairie area, primarily for stock watering purposes but with the gradual realization that some of them have fish-producing possibilities. Thus the Fisheries Branch of the Saskatchewan Department of Natural Resources has received increasing numbers of requests for stocking, but has insisted that indiscriminate stocking must be avoided. For this reason much of the pond fish program to date has been concerned with limnological studies to determine the factors which limit fish production in our ponds, and preliminary tests to show what species are best suited to this area. A few older ponds have populations of minnows, perch and other fish. These have been useful as an indication of the mature communities which may be expected to develop from our new ponds.

A questionnaire was sent to the other provinces to determine the extent of farm fish pond management in Canada, and a summary of the replies is appended. This paper, however, is confined to Saskatchewan studies.

Investigation Program

In 1948 the physical, chemical and biological conditions were investigated in 71 bodies of water during a four-month period. The two-man field party was provided with a mobile unit including truck, boat and appropriate limnological equipment. The information obtained made possible a preliminary classification of these waters and pointed to the need for special studies of winter stagnation and winter-kill of fish. Such studies were initiated in the winter of 1948-49. In the summer of 1949, 15 ponds were selected for seasonal observation and 35 new ponds were studied. Winter studies were continued and in the summer of 1950, 12 new ponds were examined and 12 selected from the total (118) for intensive work. This included preliminary tests of fertilization, both for food production and weed control, also tests of the effect of reducing the fish population in two ponds believed to be overstocked.

The first three years of the program were supported jointly by grants from the National Research Council of Canada and the Department of Natural Resources of Saskatchewan. In 1951, it was decided that we were ready for developmental work in fish culture and the program was therefore taken over by the Provincial Department. Ponds have been constructed for controlled rearing tests at the Provincial Hatchery at Fort Qu'Appelle. Preliminary introductions have been made in eight ponds and studies of weed control, winter-kill and population pressure are being continued.

POTENTIAL FISH PONDS IN SOUTHERN SASKATCHEWAN

The semi-arid climate of the grasslands of southern Saskatchewan puts a premium on water supply. Thus most of the reservoirs in the area are constructed primarily to supply water for stock-watering or irrigation. Two types of construction are common, dugouts excavated with heavy machinery and ponds or reservoirs, created by damming small coulees (valleys). A very small proportion of our ponds have the benefit of natural inflow from springs. The importance of these water supplies is recognized by the Federal Government and free assistance is provided under the Prairie Farm Assistance Act, in the form of advice and engineering services. Heavy equipment is also made available for the construction of dams and dugouts at a nominal charge. Such assistance is available both for individual farms and for larger community projects. During the past 15 years there have been constructed in Saskatchewan, with P.F.R.A. help, about 25,000 dugouts, 3,800 stock-watering dams and 150 community reservoirs of somewhat larger size.

The dugouts commonly constructed are 60 by 160 feet, 10 to 14 feet deep and with a minimum drainage of 50 acres. It was considered unlikely that these would sustain fish populations but this opinion had to be tested. Yellow perch have survived the winter in at least one dugout. The stock-watering reservoirs vary considerably in area, depth, water level stability, weed growth and general productivity. Thus a wide range had to be examined to provide a classification and determine the critical factors. In addition, a few large reservoirs and two small lakes were studied for the light which they might shed on the problems of the smaller fish ponds.

PHYSICAL AND CHEMICAL CONDITIONS

For water supply, the great majority of Saskatchewan ponds are dependent on the spring run-off. In the study period of four years, this was usually adequate to fill the reservoir to a desirable level. The spring of 1948 had unusually low run-off in the southwest, and in 1949, the precipitation was very low, thus showing many ponds in their worst condition. In at least four instances, violent spring flooding washed out the dams and temporarily destroyed what had appeared to be promising fish ponds. Water levels often declined gradually during the summer but usually not more than one foot below the spring level. Some reservoirs have been rejected because of wide fluctuation in level. The autumn level is a critical matter and the heavy ice cover further reduces the volume of water available to fish.

Area is not considered of great importance for fish production, but ponds less than one-half acre in area are rarely satisfactory in other respects. Depth on the other hand is really critical. A maximum depth of 15 to 20 feet is desirable and a depth of 15 feet over a considerable fraction of the pond is considered essential. In shallower ponds winter stagnation and winter kill of fish are likely to occur. Sharp (1950) reports complete winter kill of fish in 11 of 20 ponds in adjacent North Dakota.

Summer temperatures averaged about 18° C. (64° F.) and reached maxima of 24° or 25° C. (77° F.) at the surface. The bottom was usually one or two degrees cooler than the surface. Summer

stagnation was rarely encountered and never serious. Bottom oxygen was plentiful and the pH was usually between 7.4 and 8.6. Secchi disc determinations indicate light penetration usually from 3 to 5 feet but occasionally less than 2 feet during heavy phytoplankton growths. Turbidity due to erosion and suspended silt has not been important except in a few newly constructed reservoirs. Many of the ponds are fenced to keep out livestock.

The ice cover usually forms in early November and persists for nearly five months, reaching a maximum thickness of 30 to 38 inches. Winter stagnation is evident in most reservoirs during February and may become severe in late March. At this time, dissolved oxygen as low as 1.1 cc./l. has been observed with 1.5 or 2 cc./l. just beneath the ice. Winter kill of fish is known from three locations. However, yellow perch are known to have survived with less dissolved oxygen than 1.7 cc./l. and white suckers in 1.2 cc./l.

Biological Conditions

The plankton was composed of common species of entomostraca, rotifers and green and blue-green algae. The standing crop was usually in the order of 2 mg. dry weight per cu.m. Fertilization resulted in temporary increases of five-or-ten-fold magnitude. The winter plankton, taken through the ice, was mostly composed of zooplankters and usually averaged 0.5 mg. per cu.m. or less. Water blooms of *Aphanizomenon*, *Anabaena* and *Microcystis* were common in late July and August but rarely troublesome in the larger ponds.

The bottom fauna was particularly rich, averaging about 50 grams per sq.m. (500 kg./ha. or 445 lb./ac.). The winter crop was one-half to two-thirds of the summer quantities. Chironomid larvae of several species, the amphipods *Gammarus* and *Hyalella*, oligochaete worms and sphaeriids were the main constituents of the bottom fauna. Along the water's edge, mayfly and caddis larvae, adult beetles, hemipterans and gastropods were numerous. The species found are those discussed in greater detail in a report on the saline lakes of this area (Rawson and Moore, 1944).

The rooted aquatic plants most frequently found were *Myriophyllum*, *Ceratophyllum* and several species of *Potamogeton*. Emergent forms such as *Typha*, *Scirpus* and other sedges encroached from the shores especially in the more shallow ponds. Heavy growths of *Potamogeton* in certain reservoirs have resulted in excessive stagnation and oxygen depletion in the following winter.

In the first season after construction, the plankton and bottom fauna developed rather slowly. In the second they were much more numerous, and by the third year appeared to approach the full productive capacity. In several instances, ponds which were promising in the second year, later became undesirably choked with weeds. This situation and the need for controlling algal blooms in dugouts has led to an investigation of chemical control involving tests of fertilization, copper sulphate, Benochlor and several herbicides. Satisfactory and economical controls have not yet been worked out but the study is still in progress.

Native Fish

An investigation of the species, abundance and distribution of native fish

was carried out before considering the introduction of other species. The yellow perch, *Perca flavescens*, and the fathead minnow, *Pimephales promelas*, may be considered the characteristic species in small bodies of water in the grassland area. The pike, *Esox lucius*, the white sucker, *Catostomus commersonnii*, and the brook stickleback, *Eucalia inconstans*, are also numerous where they have gained access. Other fish species in the region have been listed by the senior author (Rawson 1949).

The yellow perch is a hardy and vigorous fish in this area. Unfortunately, it tends to overpopulate and is commonly too small for satisfactory angling. Although its small size is not always associated with overcrowding, some tests have shown that in Saskatchewan, as elsewhere, increased rate of growth resulted from thinning out the population. The perch feeds primarily on bottom organisms but may also take considerable quantities of plankton and minnows. It is therefore considered as a game fish which might utilize effectively the available food supply.

Perch have been used to study the problem of winter-kill in conditions of winter stagnation. Winter-kill has been observed from several ponds less than 10 feet in depth and especially in those with heavy weed growth. Tests in dugouts showed survival over winter only in one unusually deep (16 ft.) dugout. This is evidence that ordinary dugouts, usually with less than 12 feet of water, offer no promise of fish production.

The pike also thrives, especially in the larger reservoirs. Small reservoirs can support only a few of this species and, in general, it is not highly regarded as a food fish when taken from warm, shallow water. The yellow pike-perch, *Stizostedion vitreum*, has been widely planted in the past but has survived only in large deep reservoirs and cannot be regarded as a pond fish.

The fathead minnow reproduces and grows rapidly, and it provides excellent food for the piscivorous game species. It is therefore regarded as suitable, if and wherever a forage species is required. The brook stickleback is considered less desirable and the white sucker is a nuisance species which may need to be exterminated from ponds to which it gains access.

POPULATION STUDIES

Many of the older ponds had been stocked with perch and a few had other species introduced by accident or intention. These provided useful material for observation and experiment. Sampling was carried on with gill nets of 1½- and 2-inch stretched mesh and with seines. In dense populations of perch a 100-yard length of gill net frequently took 150 to 250 perch in an over-night set. Tagging and recovery were used in a few cases to obtain estimates of population.

Perch, planted in the 10-acre Brokenshell pond in 1945, were already crowded in 1948. Four-year-old perch averaged 9 inches (fork length) and 8 oz. In 1950 the population was still more dense and had an overabundance of 2- and 3-year-old fish. Four-year-old fish in 1950 averaged only 7.6 inches and 3 oz. The growth rate had declined in two years by nearly 30 per cent.

Perch in the Willows pond near Assiniboia were greatly reduced in 1947 when floods washed out most of the dam. This thinning-out had a favorable

effect on size and fatness of the perch for the next two years, but by 1951 the pond was again overpopulated and the growth rate reduced.

Tests are in progress to determine the possibility of improving growth of perch by mechanical thinning. Largemouth bass have been introduced into three, and pike into two, perch populations to test the more usual practice of control by piscivorous game species. Our hope is to use the yellow perch, a native species, instead of introducing bluegills to provide angling and food for a larger game species.

INTRODUCED SPECIES

Introductions of largemouth (*Micropterus salmoides*) and smallmouth bass (*M. dolomieu*), bluegills (*Lepomis macrochirus*) and crappies (*Pomoxis* spp.) were made in southern Saskatchewan 20 years ago with no success. In the years 1936 to 1942, the senior author (Rawson, 1943) demonstrated the feasibility of rearing smallmouth bass in the waters of Prince Albert Park. The earlier failure of introductions of warm water species indicated the need for rearing pond experiments where the stock could be observed under controlled conditions. Ponds for this purpose were constructed at the Provincial Hatchery at Fort Qu'Appelle in 1949. These were 84 feet square and 12 feet deep. Initial difficulties with porosity of the soil were met by lining the ponds with a layer of bentonite. The ponds were filled in the autumn of 1950 and stocked respectively with 3-inch white crappies, largemouth bass and adult bluegills. These fish all died in late winter presumably from starvation. Water circulation maintained the oxygen supply, but the new ponds had developed no food supply and the heavy ice cover prevented artificial feeding.

In late summer of 1951, plantings of adult and fingerling largemouth bass were made in three selected reservoirs. These are now under observation.

CONCLUSIONS

It is believed that our program of limnological investigation and experiment before planting, although it may have postponed fish production, has been more than justified by saving in effort and expense. A high proportion of the smaller ponds examined have proved to be unfit for fish production.

The critical factors for ponds in this area are depth, constancy of water supply and freedom from weed choking. The severe climate, with 5 months of thick ice cover, is conducive to winter stagnation and winter-kill of fish. In general it has been concluded that few ponds less than 1 acre in area should be used and that a minimum depth of 15 feet over at least one-third of the area of the pond is desirable.

Of 118 ponds examined, 75 have been eliminated, mostly because of shallowness. In general, realizing the limitations of small ponds on individual farms, the people of rural Saskatchewan are now showing greater interest in larger reservoirs. Most of these have areas of more than 50 acres and are usually constructed as community projects.

The program planned for the immediate future includes experiments with several species of warm-water game fish including black bass and yellow perch. The main aim will be to find species which will overwinter successfully and techniques which will prevent overcrowding.

ACKNOWLEDGEMENT

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FARM FISH PONDS IN CANADA

Summary of information obtained by questionnaire, January, 1952.

Five provinces reported no farm fish ponds. These were: **Newfoundland**, reported by A. A. Blair, St. Johns, Newfoundland; **Nova Scotia**, reported by F. R. Hayes, Department of Zoology, Dalhousie University, Halifax, Nova Scotia; **New Brunswick**, reported by M. W. Smith, Atlantic Biological Station, St. Andrews, New Brunswick; **Manitoba**, reported by G. E. Butler, Department of Mines and Natural Resources, Winnipeg, Manitoba; **Alberta**, reported by H. B. Watkins, Department of Lands and Forests, Edmonton, Alberta.

Quebec and **British Columbia** reported very few ponds. Mr. G. Prévost, Department of Fish and Game, Montreal, Quebec, reports that in the very few ponds in that province, eastern brook trout are raised and that the stock is obtained from private hatcheries. Mr. S. B. Smith of the British Columbia Game Department, Vancouver, reports that there are less than fifty ponds in B. C., almost all of which have been built during the past five years. Rainbow trout purchased from the Government hatcheries are used to stock these ponds. The construction of small ponds is not encouraged.

For **Ontario**, Mr. H. H. MacKay, Department of Lands and Forests, Toronto, reports about 70 ponds. These ponds are used to produce eastern brook trout, largemouth and smallmouth bass, brown trout, rainbow and minnows. About half of these provide good fishing. Fertilization has been used to a very limited extent.

For **Prince Edward Island**, Mr. M. W. Smith reports about 100 ponds, most of which were originally millponds. Eastern brook trout are used exclusively, and are obtained from Federal fish hatcheries. Further details are provided in Mr. Smith's paper in "Canadian Fish-Culturist", Number 11, October, 1951.

WINTER MORTALITY OF MULE DEER IN UTAH IN RELATION TO RANGE CONDITION [1]

W. Leslie Robinette, Odell Julander, Jay S. Gashwiler, and Justin G. Smith [2]

The winter of 1948-49, one of the severest recorded in Utah since the inception of weather stations, focused the attention of the public upon the welfare of the mule deer (*Odocoileus hemionus*) herds in the State. Widespread deer depredations on orchards and haystacks and on ornamental shrubbery in cities and towns were indicative of the desperate plight of the herds. The Utah State Fish and Game Commission was besieged with demands that various deer herds be fed. Considerable feeding was done and although it served to reduce damage to orchards and to ornamental shrubbery in cities and towns adjacent to winter deer range it did not prevent heavy winter mortality.

Severe winters come periodically. Is it inevitable that deer herds suffer drastic losses in these unusual years? Feeding is definitely not the answer. Would an adequate supply of range forage prevent these periodic calamities in our deer herds?

[1] Contribution of the Utah Cooperative Big Game, Livestock, and Range Relationship Project conducted jointly by the Utah State Fish and Game Commission, U. S. Forest Service, U. S. Fish and Wildlife Service, and Utah State Agricultural College.

[2] Robinette and Gashwiler are biologists with the U. S. Fish and Wildlife Service, Salt Lake City, Utah; Julander and Smith are range conservationists with the Intermountain Forest and Range Experiment Station, U. S. Forest Service, Ogden, Utah.

The purpose of this study was to determine the extent of winter mortality for several selected sample herds and the relationship of these herd losses to the available native forage. Accordingly, three areas, varying from extreme depletion to good condition, were selected for intensive study on which both winter herd mortality and quantity of available forage were determined. In addition, data for winter herd mortality on other areas for moderate and severe winters are given.

In this study the writers wish to acknowledge the assistance rendered by: D. M. Gaufin, Big Game Supervisor, Harold Crane, Assistant Big Game Supervisor, E. D. Stapley, Clifford Ashman, and Roy Garrard, Game Wardens, of the Utah State Fish and Game Commission; Everett Doman, Range Examiner, and Victor Stokes and Carl Haycock, Forest Rangers of the U. S. Forest Service; John Day, Zubert Castino and Ren Walters, sportsmen; and C. M. Aldous, Regional Biologist of the U. S. Fish and Wildlife Service.

Wintering Conditions for Utah Deer

Mule deer in Utah normally frequent the lower mountain slopes at elevations varying between 5,000 and 7,500 feet during the wintering period from late November until mid-April or early May. Except for short periods following

fresh snowfalls the south exposures in the foothills are bare during most winters. However, snow accumulates to depths of 2 feet or more on the north-facing slopes. Extended periods of freezing weather are uncommon.

During the winter of 1948-49 exceptional cold and snow commenced in late November and continued unabated until mid-February. The U. S. Weather Bureau (1949) summed up their records for the winter by stating: "The average temperature for the three winter months of December, January, and February equalled the record low mark established in 1932-33. However, no other winter could compare with this season's snowfall totals and depth on the ground records." Snow within the winter deer range attained depths of 2½ to 3 feet on the level throughout the northern and western parts of Utah including the study areas, but averaged about a foot less in the southeastern part.

The deep snows and low temperatures prevailing during the winter of 1948-49 created unusual hardships for the deer herds. Not only was there a much greater than normal dissipation of body energy from the deer because of the continued subfreezing temperature but the snow covered much of the low-growing forage and restricted the movements of deer in their search for food.

STUDY AREAS

The three areas selected for intensive study represented varying degrees of browse abundance and overstocking by deer. Overgrazing by domestic livestock in the past had destroyed most of the perennial grass cover on each of these areas. However, this paper is concerned only with browse species and it is evident that deer are primarily responsible for the present condition of browse on these particular ranges.

One of the areas, Meadow Creek, is located about 40 miles southwest of the geographic center of the state and on the west slope of the Pavant Mountain Range. Juniper (*Juniperus utahensis*) and sagebrush (*Artemisia tridentata*) are the dominating browse species and liberal amounts of cliffrose (*Cowania stansburiana*) and bitterbrush (*Purshia tridentata*) plants are interspersed. This area has been overstocked with deer since the late 1930's. Pronounced hedging of the bitterbrush, highlined and dead cliffrose, dead sagebrush on the south exposures, and highlined junipers are the symptoms of range depletion exhibited on this unit.

Another study site, South Oak Creek, is on the west slope of the Canyon Mountains about 40 miles north of Meadow Creek. This unit has some of the best winter deer browse to be found in Utah. Besides an abundance of juniper and sagebrush there are extensive areas of cliffrose with scattered amounts of bitterbrush, true and curl-leaf mountain-mahogany (*Cercocarpus montanus* and *C. ledifolius*), and gambel oak (*Quercus gambelii*). Overuse of the better browse was evident in the late 1930's but heavy doe removals during the period 1940-42, largely corrected the problem before permanent injury was done.

The third site, the Heaston Game Preserve, is on the west slope of the Oquirrh Mountain Range and only a few miles from the south end of Great Salt Lake. The lower part of this winter range is covered chiefly with

annual grasses and forbs which are considered very poor winter deer forage. Small amounts of juniper and curlleaf mountain-mahogany appear along the upper reaches of the wintering area but they no longer produce usable forage because a sharp highline exists and the foliage lies above the reach of deer. Palatable low shrubs occur only as hedged or dead remnants. Only oak and sagebrush furnish appreciable amounts of browse, and even these species are restricted in their distribution. Range fires have been instrumental in reducing the sagebrush cover over part of this unit. Considering the small amount of browse available per deer and the severe overuse of the browse that is available, this winter deer range is one of the most impoverished in Utah, and despite heavy losses of deer prior to the time of study it was still badly overstocked in 1948-49.

As a measure of the ability of winter range to support deer, the winter of 1948-49 provided a crucial test for the above areas.

DEER MORTALITY

Meadow Creek.—During the late spring after the deer had left the winter range six technicians made pellet group counts on one-hundredth-acre plots equi-spaced along six transects which extended from the lower to the upper edge of the winter range. This range was initially divided into three blocks and within each block two transects were randomly located. All transects were parallel to one another. While the technicians were engaged in the pellet group counts they encountered 13 deer carcasses. Each carcass was marked to permit subsequent identification. On the following day 10 riders, spaced about 125 feet apart to prevent overlapping of each individual's cruise strip, made a dead deer survey along 4 randomly selected strips which were at right angles to the survey lines of the previous day. A total of 73.6 deer carcasses [3] were found on the ride. Only 4 of the 13 carcasses marked during the previous day were observed on the horseback survey. The Lincoln Index (Lincoln, 1930) gave a mortality of 239 animals (13 : 4 :: X : 73.6).

In addition to this method of evaluating deer mortality the King Census Method (Leopold, 1933; Trippensee, 1948) was used in which participants riding horseback obtained sight distances for the carcasses. At the instant a carcass was sighted the rider dismounted and paced the distance between himself and the dead deer. Other observers waited in line until the signal to proceed was given. Altogether 73.4 man miles of survey lines, foot and horse travel combined, were covered. In this distance 85.8 dead deer were seen. The average distance at which the carcasses were first sighted was 40.5 feet yielding an effective survey strip of 81.0 feet. On this basis 721 acres were covered and for the 2,182 acres of winter range there were a calculated 259 dead animals. Since there is no reason to favor the results of one method over those of the other, they have been averaged to give 249 dead deer for the area.

[3] Because carcasses are often scattered by feeding coyotes, the writers have assigned fractions to parts such as legs and vertebral column. Thus a leg is recorded as 2/10 of a deer instead of being accorded the same weight as a whole animal. This procedure is necessary to prevent exaggerated mortality calculations.

The wintering population of deer was determined from pellet group counts (Bennett, *et al.*, 1940; McCain, 1948). The period during which the herd was on the winter range was determined from careful observations of seasonal deer movements on other areas in central Utah to be from about December 1 through April 20 or 141 days. The pellet group method is particularly well adapted for censusing deer in Utah. The winter and summer ranges of the deer are fairly distinct and differential weathering permits one to distinquish pellet groups of the past winter from those of the preceding winter. In Utah, Rasmussen and Doman (1943) made pellet group counts within a fenced area containing a known number of deer. From their results it can be determined that the average defecation rate for mule deer is about 12.5 groups per day. On the basis of the foregoing information the wintering population for the Meadow Creek unit has been calculated as follows:

Number 1/100 acre plots taken	284
Number current pellet groups	1,945
Pellet groups per acre	685
Acres of winter range	2,182
Expected pellet groups on area	1,494,670
Deer days spent on area (1,494,670 divided by 12.5)	119,574
Number deer on area (119,574 divided by 141)	848

The population as derived above does not truly represent the number of deer on the unit at the start of winter for a calculated 249 head died around midwinter. The peak of the loss is believed to have occurred about February 15. The 249 deer which died would have deposited an additional 199,200 pellet groups had they survived. The addition of these groups to the original number of 1,494,670 and subsequent division by the daily defecation rate and number of days spent on the area by the herd yields a probable total of 961 deer for the area at the start of winter. Using this figure as a base, over-winter losses were approximately 26 percent of the herd.

South Oak Creek.—The 1948-49 winter mortality on this unit was determined by the King census method only. The number of carcasses found was too small to permit effective use of the Lincoln Index.

A total of 121.5 man miles with an effective survey strip of 55.8 feet wide were covered. This gave an acreage of 822 surveyed out of a total of 7,864 acres for the unit. Only 11.4 deer carcasses were found on the strips which gave a total of 109 dead deer for the area.

Based on a systematic survey, 858 pellet groups were recorded on 311 one-hundredth-acre plots. Careful observations indicated a wintering period of 144 days (November 28 to April 20) and a peak winter deer mortality at about February 15. The calculated prewinter population, adjusted as on the Meadow Creek area for winter deaths, was 1,255 deer. The herd loss was thus determined to be 9 percent.

Heaston.—On this unit the Lincoln Index was the only method used in arriving at the deer mortality. The precipitous slopes along the upper reaches of the winter range precluded any systematic riding of the unit so that results from the King census method would be of doubtful value. A preliminary survey was made of the severity of the 1948-49 winter loss by two observers afoot. They marked 28 dead

deer by removing an ear from each animal. This check extended from the lower to the upper portion of the wintering range and was restricted to one small drainage. A subsequent horseback survey by seven participants was made along the base of the steep mountain slope at right angles to the small drainage covered in the preliminary check. On the horseback survey only 5 of the 48 carcasses seen had been marked. The proportion equation set up from the above data gave an expected mortality of 269 deer (28 : 5 :: x : 48).

Surveys showed 424 pellet groups on 147 plots on the 2,907 acres of winter range. Using an estimated 124-day winter period (December 1 through April 3) and correcting for winter deaths the calculated prewinter herd was 644 deer. The herd loss was therefore approximately 42 percent.

It is recognized that there may be considerable sampling error in the above data for the three study areas. A recent application of confidence limits to populations determined by the Lincoln Index (Adams, 1951) suggests large errors in the present data from this method. However, data obtained by two different methods at Meadow Creek are in close agreement. In addition, data from other methods used on the entire Oak Creek unit (Julander and Robinette, 1950) agree closely with the South Oak Creek data presented in Table 2 for moderate winters. Field observations, aside from those made on the sample plots themselves, also corroborate the relationships shown by the data given for the three study areas. These related lines of evidence lend confidence to the results of the present studies.

RELATION OF FORAGE TO MORTALITY

The amount of forage present was determined by weight estimates on line plot transects (Pechanec and Pickford, 1937). Forage was estimated by species in grams green weight on plots 96 square feet in area which may be converted directly to pounds per acre (Frischknecht and Plummer, 1949). Forage as referred to here includes all leaves and current shoot growth present to a height of 5 feet above ground.

As shown by Table 1, browse is well distributed over South Oak Creek range. Good browse occurs on 38.7 percent of the plots. Fair browse occurs on most of these same plots and also on an additional 37.3 percent so that 76 percent of the plots have either fair or good browse or both. Twenty-two percent of the plots have only emergency browse and 2 percent are without browse. Forage is adequate to sustain deer even on the stress areas where deer concentrate in severe winter weather.

South Oak Creek has a much better supply of good browse, emergency browse, and total browse than the other two areas. The presence of 108 pounds per acre of good browse and the fact that in general the browse plants are vigorous are indicative of a relatively good range condition for deer. Since juniper and cliffrose occur in nearly pure stands over large areas of South Oak Creek, the distribution of sagebrush is somewhat restricted. This accounts for the relatively low volume of fair browse on this unit.

Meadow Creek range differs from South Oak Creek chiefly in quantity and distribution of forage. Good forage plants are still present but are badly overbrowsed. Although a fair volume of

TABLE 1.—VOLUME WEIGHT PER ACRE (GREEN) AND FREQUENCY OF OCCURRENCE OF BROWSE ON THREE UTAH DEER WINTER RANGES

Condition of Browse and Species	South Oak Creek Weight (lbs/A)	South Oak Creek Frequency (%)	Meadow Creek Weight (lbs/A)	Meadow Creek Frequency (%)	Heaston Weight (lbs/A)	Heaston Frequency (%)
Good browse:						
Purshia tridentata	2.0	...	9.2	...	0	...
Cowania stansburiana	88.0	...	30.9	...	0	...
Cercocarpus ledifolius and *C. montanus*	17.9	...	1.8	...	0	...
Subtotal	107.9	38.7	41.9	33.5	0	0
Fair browse:						
Artemisia tridentata	158.2	...	327.6	...	110.6	...
Quercus gambelii	36.8	...	3.4	...	67.7	...
Minor species	4.5	...	0	...	0	...
Subtotal	199.5	[1]37.3	331.0	[1]54.3	178.3	[1]50.5
Poor or emergency browse:						
Juniperus utahensis	907.7	...	279.0	...	0	...
Gutierrezia sarothrae	16.1	...	0	...	33.9	...
Chrysothamnus sp.	28.2	...	0	...	0	...
Minor species	0	...	22.9	...	2.7	...
Subtotal	952.0	[2]22.0	301.9	[2]9.3	36.6	[2]9.0
TOTAL	1,259.4	98.0	674.8	97.1	214.9	59.5

[1] Includes plots having fair or fair and poor browse but not good browse.
[2] Includes plots occupied only by poor or emergency browse.

sagebrush is shown (Table 1) for this area, depletion is especially serious on south and west slopes where forage is most needed in midwinter. On such areas even the poorer forage such as juniper is inadequate to serve as emergency forage in periods of distress because of previous highlining.

The Heaston range is inferior in quantity, quality, and distribution of forage. There is practically no good forage. Fair browse (oak and sage) makes up 83 percent of the forage but it occurs on only half of the plots. Much of the volume of fair forage occurs on north slopes and at higher winter range elevations and is not available to deer during winters of deep snow. Emergency browse is very scarce. No available juniper occurs on this area since the relatively few trees present are all sharply highlined. About 40 percent of

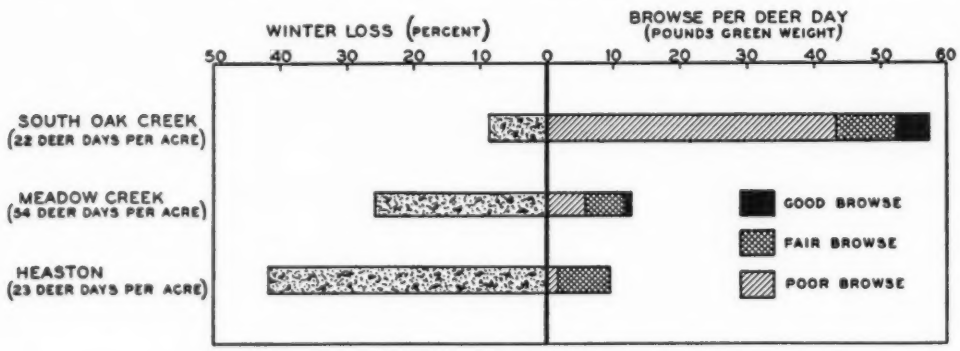
WINTER LOSS (PERCENT)
BROWSE PER DEER DAY (POUNDS GREEN WEIGHT)
50 40 30 20 10 0 10 20 30 40 50 60
SOUTH OAK CREEK (22 DEER DAYS PER ACRE)
MEADOW CREEK (54 DEER DAYS PER ACRE)
HEASTON (23 DEER DAYS PER ACRE)
GOOD BROWSE
FAIR BROWSE
POOR BROWSE

FIG. 1. Winter deer losses are inversely related to the amount of available browse.

this range, including much of the mid-winter stress area, supports nothing but annual forbs and grasses which are of little value in winter.

Fig. 1 shows the relationship between available browse and winter mortality.

Rate of stocking on a per acre basis is about the same for South Oak Creek and Heaston. Meadow Creek's rate of stocking is over twice as great as for the other two. A comparison of browse present per deer day shows that the South Oak Creek deer have four to six times more winter forage than deer at Meadow Creek and Heaston. Meadow Creek deer are better provided for than those at Heaston especially when distribution and availability of forage are considered.

Winter loss was inversely related to the forage supply. The South Oak Creek herd showed a winter loss only slightly in excess of the average (8 percent) for this area during the two previous open winters. Here even on areas where deer were most concentrated, there was some good and fair browse and plenty of emergency browse for critical winter periods. On the depleted Meadow Creek range the percentage of winter loss was nearly three times that of South Oak Creek. The stress areas where deer concentrate in severe weather were short of forage—even emergency forage—because of previous highlining and severe hedging of trees and shrubs. Percentage winter loss of deer on the severely depleted Heaston range was almost five times that suffered at South Oak Creek. Malnutrition from lack of desirable forage is believed to be the primary cause of mortality here. However, the scarcity of juniper for protection as well as for emergency feed on the Heaston range no doubt had additional influence on winter mortality. The areas preferred by deer in midwinter on this range are so impoverished of browse that even in open winters forage is very inadequate as attested by an estimated 40 percent loss in the relatively mild winter of 1947-48 (Gaufin, 1948). Had it not been for this very heavy loss and a heavy kill by hunters in 1948, the winter mortality of 1948-49 would very likely have been much higher than the 42 percent which was recorded.

COMPARISON OF WINTER DEER MORTALITY IN MODERATE AND SEVERE WINTERS

How do deer losses in normal winters compare with those of the severe winter of 1948-49?

Results of some surveys (unpublished) made by the authors are listed in Table 2 for comparison.

The individual mortality surveys for the moderate winters on each of the four areas listed in Table 2 were less intensive than the 1948-49 surveys, and therefore greater sampling errors might logically be expected. Actual results for three moderate-winter surveys given below give a rough indication of these sampling errors:

	1945–46	1946–47	1947–48
Bellyache.....	14	15	..
Manning Creek....	..	16	7
Durke Springs.....	..	0	11
South Oak Creek..	..	10	5

The writers are well acquainted with deer wintering conditions on each of the areas listed above and they doubt that for the Manning Creek, Durke Springs, and South Oak Creek areas the actual loss varied as much during the moderate

TABLE 2.—COMPARATIVE DEER HERD LOSSES IN CENTRAL UTAH FOR MODERATE AND SEVERE WINTERS ON DEPLETED RANGES AND RANGES HAVING ADEQUATE FORAGE

Area	Range Condition	Winter Herd Mortality (percent)	
		Moderate Winter	Severe Winter
			1948–49
Bellyache	Severely depleted	[1]14	27
Manning Creek	Severely depleted	[2]12	20
Durke Springs	Fair—adequate forage	[2] 6	9
South Oak Creek	Good—adequate forage	[2] 8	9

[1] Average for 1945–46 and 1946–47.
[2] Average for 1946–47 and 1947–48.

winters as the survey data indicated. It is strongly believed that sampling error was primarily accountable for the wide fluctuations and that the averages listed in Table 2 more closely represent the actual losses during moderate winters than the figures for individual years shown above.

The Bellyache and Manning Creek areas have been overstocked with deer for many years and the hundreds of highlined juniper and pinyon pine trees, hedged bitterbrush, and dead stubs of sagebrush are mute attestations to this fact. The average winter deer mortality rates on these two units almost doubled from the mild winters to the severe one. By way of contrast the two units with an adequate supply of browse exhibited increases of only 1 to 3 percent in herd mortality. It can be concluded that essentially all of the differences between herd losses in 1948-49 on depleted range and ranges with adequate forage can be attributed to malnutrition.

During the winter of 1948-49 the Utah State Fish and Game Commission (1949a, 1949b) reported losses ranging from 30 to 50 percent for deer herds from Nephi northward to the Idaho line along the Wasatch Front (including the Heaston herd reported herein). The authors believe that average herd losses for this region probably do not exceed 10 percent in moderate winters. The observations reported above tend to confirm this view.

DISCUSSION

Many sportsmen were prone to blame the heavy losses of 1948-49 upon an inadequate feeding program. Others took the view that in such severe winters nothing could be done to forestall serious herd losses. Studies by Doman and Rasmussen (1943) indicate the fallacy of these viewpoints. They reported a winter loss of 22 percent in 1942-43 on a depleted northern Utah range where feeding was done, while on a nearby range with adequate native browse the mortality did not exceed 5 percent. The results of the present study agree with this earlier work and emphasize the special need of adequate forage in severe winters.

Drastic losses may occur during normal winters when deer herds reach an irruptive peak (for example, as for the Kaibab herd). However, the spread between winter herd losses on overstocked and moderately stocked ranges is usually not as pronounced during normal winters as in severe winters. The

values listed in Table 2, as well as general observations of other Utah herds, suggest that losses are increased disproportionately during severe winters on overstocked ranges as compared to moderately stocked ones. It seems possible that a herd could be virtually annihilated should its irruptive peak coincide with an unusually severe winter.

The wastefulness of overstocking by deer is not generally appreciated. The disaster of the Kaibab herd—in four years the capital herd was reduced by 53,000 deer through starvation while only about 6,000 were taken by hunters (Rasmussen, 1941)—is an extreme example of waste. However, similar disasters have been repeated many times on smaller scales in many parts of the United States.

This type of wastefulness is also displayed on the areas studied when data on the South Oak Creek and Heaston deer herds and ranges are compared (Fig. 1). South Oak Creek has about the same number of deer per section as Heaston but about six times the amount of forage per deer day's use and the forage is of higher quality. The percentage loss for the South Oak Creek herd as stated previously was less than one-fourth that for the Heaston herd. About 25 percent of the basic herd in Oak Creek is harvested annually by hunters and both the breeding herd and deer winter range are being maintained. Heaston with about the same deer density is being destructively grazed, starvation is taking many more deer than hunters are harvesting, and both deer numbers and winter range are rapidly retrogressing.

Overstocking is destructive to the range as well as wasteful of deer. Although some estimates of loss in grazing capacity have been made, the full measure of destruction on depleted deer ranges has never been fully determined. What is top soil worth? What are the costs resulting from a damaged watershed? Stopping accelerated soil erosion and restoring soil and browse plants is a costly and long-time process.

Studies reported in this paper give added strength to the convictions of big game managers that it is good business to stock the ranges moderately. Although sufficient data are not available for definite conclusions on optimum range use by deer it is generally agreed that utilization of the current year's growth of the more palatable browse species should not exceed 60 to 65 percent. The authors believe that stocking on the basis of about 50 percent utilization of the palatable browse on the important deer foraging grounds during moderate winters should result in high sustained forage production and a minimum mortality in severe winters.

A conservative degree of utilization of the choice browse plants is vitally important to the welfare of deer herds in a variety of ways. It not only insures the perpetuation of a maximum forage yield but the reserve of forage thus provided may spell the difference between wholesale winter losses and only nominal losses during very unusual winters such as 1948-49. Deep snows tend to restrict the amount of forage per deer through cutting down the daily cruising radius of each deer as well as making unavailable much of the low-growing forage. It is therefore obvious that deer wintering on depleted ranges where malnutrition losses occur even in average winters are in a particularly precarious

position during severe winters. Maintenance of a carry-over reserve of unused forage from year to year appears to be the best means at our disposal for preventing abnormally high losses during severe winters.

SUMMARY

Deer mortality and range condition studies were made following the winter of 1948-49 which, according to the U. S. Weather Bureau, was the severest Utah winter on record. Detailed studies on three Utah winter mule deer ranges revealed that winter deer loss varied inversely with the forage supply. Herd losses of 9, 26, and 42 percent were determined for the three areas on which forage inventories showed that there has been respectively 57, 13, and 9 pounds of green forage present at the start of winter for each deer day of use on the areas. As winter closed in much of this forage was made unavailable resulting in serious food shortages on the two overbrowsed ranges.

Observations of winter deer losses on the study areas and in other herds during moderate and severe winters indicate that on properly stocked ranges the loss is only slightly greater during severe winters than it is during moderate winters. On the other hand, the loss on depleted ranges in severe winters may exceed the mortality incurred during a moderate winter by several times.

It is concluded that moderate stocking of deer is necessary to maintain the forage yielding capacity of the ranges, soil and watershed values, and in addition, the health and well-being of the herds.

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EFFECTS OF SOME HERBICIDES AND INSECTICIDES ON BIOTA OF NORTH DAKOTA MARSHES [1]

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Various writers such as Gerking (1948), Snow (1949), and Steenis (1950) have commented on the value of 2, 4-D for improving aquatic habitat for fish and wildlife. One seldom reads, though, of the harm this herbicide can inflict on wildlife food and cover when not carefully used, whether in upland or marsh.

The hazards of insecticides have been better recognized. Even so, as Couch (1946) said about DDT, "In agriculture and forestry, potential dangers have not been fully appreciated," and his statement could well be extended to other chemical controls. In view of these hazards, Baumgartner (1948) advised against spraying with insecticides, particularly in aquatic habitats, until effects on the fauna could be studied.

In North Dakota, the airplane has rendered small marshes vulnerable to damage due to their interspersion with agricultural land. When farmers have their land treated, pilots often spray the potholes also when it is inconvenient or difficult to avoid them. Also, publicly owned waters are sometimes poisoned by private individuals either through carelessness or under the impression that it will eliminate unwanted insects in the general region. In addition, some spraying of the edges of marshes is done by ground operators. Naturally, it is hard to estimate the amount of aquatic habitat sprayed unnecessarily, but it must be fairly great.

Approximately 3,190,000 acres were

[1] Contribution from Pittman - Robertson Project 7R, North Dakota Game and Fish Department. Roy N. Bach, Coordinator, Federal Aid Division, conceived the need for this research and laid the early plans for its execution. Jack R. Challey assisted in the field and laboratory work, and the chemical analysis of water samples was made by Robert L. Francis, North Dakota Department of Health. I am very grateful to Walter P. Taylor, Unit Leader, Oklahoma Cooperative Wildlife Research Unit, and F. M. Baumgartner, Associate Professor of Zoology, Oklahoma Agricultural and Mechanical College, for editorial advice and assistance.

subjected to chemicals in North Dakota in 1949. Of this total, 2,990,000 acres were treated with 2, 4-D (Widdifield, 1949), and 200,000 acres were treated with various insecticides (Colberg, 1951). Although most of the chemical application was from the ground, 350,000 acres were sprayed or dusted from the air with plant or animal poisons (Vavra, 1949). The magnitude of chemical application in 1949 is seen from the fact that it amounted to over 15% of the cultivated area of the state.

In view of these considerations, experiments were carried out to study the effects of five commonly used poisons on the biota of marshes and potholes. Those tested were 2, 4-D amine with water, 2, 4-D ester with oil, DDT with oil, chlordane with water, and toxaphene with oil.

METHODS

The experiments were devised to duplicate as closely as possible the aerial spraying carried on by farmers and ranchmen.

All of the treatments were applied by plane early in the morning on July 6, 1950, except the 2, 4-D amine, which was applied at noon on July 5, 1950. Spraying was later than usual in North Dakota because of the very retarded spring, but the plants were at about the stage of growth when spraying normally occurs.

Oil applied with some of the sprays was No. 2 Diesel fuel employed in respective experiments in approximate gallons per acre as follows: 2, 4-D amine, about 0.08 (oil in original emulsion); 2, 4-D ester, 1.15; DDT, slightly less than 1.0; chlordane, about 0.06 (oil in original emulsion); and toxaphene, 2.0.

The problem of adequate checks was met by selecting marshes traversed by roads so that a control and study area could be part of the same marsh. Each marsh sprayed was of average water stability, and in all cases the control and study areas were connected during periods of high water. Chemical analyses of water were made, but since this was done some time after samples were collected, they may not have been significant.

On the tracts sprayed with insecticides and also on their controls, three enumerations of birds and nests were made prior to spraying. After spraying, five counts of live and dead birds and of bird nests were taken. A similar number of mammal censuses was made on each area before and after treatment.

Collections of some invertebrates were made by an apron net and fine mesh dip net. Two or three samplings prior to treatment indicated in general the relationship of sprayed and study areas to each other. At least six net collections were made after treatment in each study and control area. At each marsh sprayed with insecticides, the water was sampled over a distance of about two hundred yards every time a net collection was made. The amount of water investigated depended on the size of the marsh and the time available on the date when sampling occurred. Generally though, the sampling was close to the above figure. The amounts of water studied (distances through which sampled) were eventually adjusted to a standard so all marshes could be compared. Among invertebrates, only

the larger insects, the snails, and some crustaceans (apparently all ostracods) were counted.

These collecting methods thus precluded the study of certain vertebrates and invertebrates, but were the best that could be done with the help and time available.

Although efforts were made to sample some invertebrates quantitatively, many variables made this difficult. Dense plant growth, falling water levels, and other factors prevented determinations reflecting more than a general population trend.

In the 2, 4-D experiments, live and dead dicotyledonous plants were counted on line transects totalling 550 feet long and two inches wide. These plants were principally restricted to one location, as indicated later.

The monocotyledons were studied by counting the live and dead stems touching a string fifty feet long. Ten counts of this length were made on each strip sprayed with 2, 4-D in representative stands of plants. Where damage was light, as in the insecticide experiments, only visual estimates were made. The plant survival and mortality results are also approximations.

AREAS SPRAYED AND RESULTS

2, 4-D Amine and Water; 2, 4-D Ester and Oil

The experiments with 2, 4-D were conducted at Rice Lake, half-way between Sterling and Wing, North Dakota. This is a large, shallow marsh with water depth that averaged only about one and a half feet during the study. Total dissolved solids were 770 ppm. and pH was about 8.

One strip across the marsh was sprayed with 2, 4-D amine and water and one strip with 2, 4-D butyl ester and oil. Each 2, 4-D transect went at right angles entirely across the marsh and adjoining springy area and was about forty feet wide and one-half mile long. Approximately two and one-half acres, therefore, were treated with each kind of 2, 4-D. The sprayed strips were almost entirely in the marsh itself.

The amine was put on at the rate of one-half pound per acre and the ester at the rate of one pound per acre.

Principal plants in the marsh proper at this part of Rice Lake were creeping spikerush, alkali bulrush, and hardstem bulrush. Other plants occurring within the sprayed transects and effects on them are given in Tables 1 & 2. Names of plants follow Stevens (1950).

Dicotyledons.—There were few dicotyledonous plants in either transect, and most of these occurred in the springy area adjoining the marsh. The same species occurred in both 2, 4-D transects and reacted similarly to both treatments. The percent of these plants killed is shown in Table 1.

TABLE 1.—APPROXIMATE PERCENT OF SOME DICOT PLANTS KILLED BY 2,4-D IN NORTH DAKOTA
(Arranged in order of abundance)

Plants	% Killed
Rydberg's Sunflower, *Helianthus rydbergii*	90
Silverleaf Potentilla, *Potentilla anserina*	100
Nettle Mint, *Stachys palustris*	50
Trailing Buttercup, *Ranunculus cymbalaria*	0
Blue Wild Lettuce, *Lactuca pulchella*	100
Bladderwort, *Utricularia vulgaris*	0
Long-Rooted Smartweed, *Polygonum coccineum*	100
Water Hemlock, *Cicuta maculata*	100
White Sage, *Artemisia ludoviciana*	0

Most of the broad leaved plants subjected to either type of 2, 4-D were killed or heavily injured. Some species in the marsh were submerged and thus escaped. Because water was used with the amine, none of the damage can be ascribed to oil in the amine treated transect.

Total change in dicotyledons on the wet meadow four weeks after spraying was not particularly apparent due to the emergence of new seedlings of various species.

Monocotyledons.—The layman thinks of 2, 4-D as affecting only the dicotyledonous plants; but these experiments, like others (Bohmont, 1949; Snow, 1949; Steenis, 1950; Surber, 1947), show that it injures many monocotyledons also, as indicated in Table 2. Almost all of the vegetation in the marsh itself (as distinguished from its adjacent springy area) belonged to the first three species in this table.

The effects of 2, 4-D ester and oil on monocotyledonous plants were generally more severe than in the amine and water treatment. Furthermore, more species were affected.

New plants did not appear within the period of study (July 5 to September 1, 1950) to restore damage in the marsh as occurred on the springy area adjacent to it.

A few insects were killed in the 2, 4-D ester and oil experiment, presumably by the oil. No effort was made to learn the quantity or groups affected. No other animals appeared to be affected by either treatment although at least six bird nests were sprayed, one of which contained young.

Chlordane

The experiment with chlordane was conducted in the south end of Rice Lake where a county road provided a segregated control area for study. This part of Rice Lake was practically identical to that already described. There were about fifteen acres in the experimental area and the same in the check area.

Treatment was at the rate of one pound per acre.

Vertebrates.—There was poor reproduction among the birds breeding on the sprayed unit. This was probably due to the chlordane, although the only dead juveniles found were five ducklings and

TABLE 2.—APPROXIMATE PERCENT OF SOME MONOCOT PLANTS AFFECTED BY 2,4-D ESTER AND OIL AND 2,4-D AMINE AND WATER IN NORTH DAKOTA (Arranged in order of abundance)

Plants	Ester		Amine	
	K*	D	K	D
Spikerush, *Eleocharis palustris*	70	90	50	60
Bulrush, *Scirpus paludosus*	90	100	20	50
Bulrush, *Scirpus acutus*	40	50	60	90
Reedgrass, *Calamagrostis inexpansa*	0	0	0	0
Wild barley, *Hordeum jubatum*	0	0	0	0
Common reed, *Phragmites communis*	0	80	0	0
Needlerush, *Eleocharis acicularis*	0	0	0	0
Sedges, *Carex* spp.	..	..	0	0
Arrowgrass, *Triglochin maritima*	30	50	..	..
Three square, *Scirpus americanus*	50	90	..	..

* K—killed; D—damaged.

two coots. The heavy vegetation, the rapid decomposition of small animals, and the considerable time required for thorough canvassing combined to give poor results in detection of dead or sick birds.

Poor reproduction is inferred from the few live juveniles seen and the known nest failure, as indicated in Table 3.

Two broods of shovelers, one brood of blue-winged teal, and one brood of pintails were present on the area prior to spraying. After treatment, the number of young started dwindling. The parent birds were seen for a time, but only the pintail successfully reared young.

No mortality among adult birds was observed or indicated. Since the old birds were evidently not affected, it is possible the pintail brood survived because it was older and larger than the other broods when spraying occurred.

A nest of American bittern was started late and the eggs did not hatch until about August 5; the yellow-headed blackbirds all hatched late too. The effects of the spray were considered to be much diminished by August 10 because insects began to increase at about that date. The young bitterns and yellow-headed blackbirds may therefore have survived because of the lessened potency of the poison.

As many as fifteen to twenty black terns could be seen at one time diving to the water to feed prior to the spraying; after treatment a tern was very rarely observed feeding.

Fewer birds were breeding on the check area, and some were of different species, but reproductive success was much greater (see Table 3). Only one dead juvenile (a coot) was found, and it was at the very edge of the narrow road dividing the two areas.

The only mammals seen on the study tract after chlordane spraying were two muskrats. One was alive and healthy, the other was discovered dead four days after treatment, but cause of death was not learned. No mammals were seen on the area before it was sprayed.

Invertebrates.—There was no appreciable difference in insect numbers between the chlordane check and study areas before spray was applied. After spraying, the insect population crashed to almost nothing in the treated part,

TABLE 3.—REPRODUCTIVE HISTORY OF BIRDS AT MARSH SPRAYED WITH CHLORDANE IN NORTH DAKOTA

Species	Nests Attempted		Birds Reared	
	C*	S	C	S
Pied-billed Grebe, *Podilymbus podiceps*	1	..	3	..
American Bittern, *Botaurus lentiginosus*	..	1	..	2
Pintail, *Anas acuta*	1**	1**	5	8
Blue-winged Teal, *Anas discors*	2**	1**	7	0
Shoveler, *Spatula clypeata*	3**	2**	8	0
Ruddy Duck, *Oxyura jamaicensis*	..	1	..	0
Coot, *Fulica americana*	3	7	13	5
Black Tern, *Chlidonias nigra*	4	..	7	..
Yellow-headed Blackbird, *Xanthocephalus xanthocephalus*	2	6	5	15
Red-wing, *Agelaius phoeniceus*	4	6	10	4
Totals	20	25	58	34

* C—control area; S—sprayed area.
** Broods brought to marsh after nest hatched elsewhere.

but no such change was seen in the control sector where there was merely a slight downward trend as the season progressed. Diptera, Coleoptera, and Odonata were the principal orders in each place.

Snails were abundant at all times and seemed to suffer little. Ostracods were apparently unharmed.

The chlordane and water application had no observed effects on vascular plants.

DDT and Oil

The experiments with DDT were carried out on a small marsh near Sterling, North Dakota that contained approximately ten acres, about two of which were control. This pothole was in a grain field, and part of the marsh had been farmed the previous year. Average depth of water during the study period was about two and one-half feet. Water analysis showed the marsh to be about neutral in reaction and that total dissolved solids were low, about 220 ppm.

Treatment was at the rate of one and a half pounds per acre.

Plant cover was sparse and consisted principally of pale smartweed (*Polygonum lapathifolium*), creeping spikerush, and northern reedgrass.

Vertebrates.—Possibly due to the shortage of vegetation here, there were no nesting birds on or adjacent to the sprayed part of the pothole.

Vegetative cover was considerably heavier in the control area, and some juvenile birds were present. However, none of the juveniles was seen on the sector sprayed with DDT and oil until the effects were practically gone. No mortality was found among birds, adult or young, but of course this was not a fair test of the effects of DDT upon young birds.

There was an average of about ten adult ducks, plus various other birds, on or near the sprayed part whenever it was inspected. After spraying, feeding on live insects ceased abruptly as was expected.

Salamanders and frogs were present in fair numbers. No special methods were used to study them other than in association with the regular invertebrate collections. No particular mortality was observed among frogs in either adults or tadpoles, but dead salamanders (*Ambystoma tigrinum*) showed up after spraying. A loss of some consequence probably occurred among salamanders due to the treatment, but there was insufficient time to study it adequately.

Invertebrates.—In general insects were completely wiped out, as shown in Table 4, and almost none was found in the pothole for five weeks after spray application. After spraying, successive bands of dead insects were washed up as the water dropped until five bands in all were recognizable.

Many shore birds, waterfowl, and other birds now gathered in numbers to feed on this flotsam. Eventually the

TABLE 4.—AVERAGE NUMBER OF INSECTS PER SAMPLING BEFORE AND AFTER SPRAYING MARSH WITH DDT AND OIL IN NORTH DAKOTA

Order	Before		After	
	C*	S	C	S
Coleoptera.....	85	65	20	3
Hemiptera.....	90	45	110	2
Diptera.....	10	95	22	T**
Odonata.....	20	10	4	0
Totals.....	205	215	156	5

* C—control area; S—sprayed area.
** Items less than 1.0, called trace.

shores were picked clean, and it was difficult to find dead insects other than some mosquito larvae. There was no indication that any birds were adversely affected by feeding on these poisoned arthropods.

No other macrocsopic invertebrates were found in measurable quantity at any time.

Plants.—There was slight damage to plants from DDT and oil. Probably no plants were killed by the spray. About 20% of the stems of creeping spikerush were somewhat burned, and about 10% of the foliage of pale smartweed was slightly marked.

Toxaphene and Oil

The toxaphene and oil experiment was made on a pothole near Sterling, North Dakota. It too was a depression among low hills, and the sprayed part was surrounded by grain fields. The marsh contained about twelve acres in all, but was divided into equal parts by a highway. This provided a control area on one side.

Treatment was two pounds of toxicant per acre.

Average depth of water was two and one-half feet, and this level remained fairly constant. The chemical analysis showed total dissolved solids low, 105 ppm., and pH nearly neutral.

Plant growth was dense and diversified in the experimental area. Most numerous plants were sedges (mostly *Carex atherodes* and *C. lanuginosa*), pale smartweed, creeping spikerush, northern reedgrass, and water plantain (*Alisma subcordatum*). Due to considerable grazing by livestock, the check area beyond the highway right-of-way had much less vegetation. Part of the check area was within the fenced right-of-way, and it had a dense growth of plants. Probably as a result of this, there were fewer birds breeding on the control.

Vertebrates.—The toxaphene and oil treatment was destructive to juvenile birds at this pothole. So far as learned, every young bird succumbed which, normally or otherwise, entered the water. The only young known to be raised here were six red-winged blackbirds from a total of twenty-one nests, as shown in Table 5.

The dead juveniles were all within a few feet of their nests, or in the case of ducklings, within twenty feet of the shore. These facts seem to indicate that the poison was fast acting.

No doubt a number of young birds died which were never found due to

TABLE 5.—REPRODUCTIVE HISTORY OF BIRDS AT MARSH SPRAYED WITH TOXAPHENE AND OIL IN NORTH DAKOTA

Species	Nests Attempted		Birds Reared		Dead Juveniles	
	C*	S	C	S	C	S
Duckling	5**	3**	20	0	0	8
Sora	..	1	..	0	..	2
Coot	2	4	8	0	1	6
Black Tern	..	8	..	0	..	8
Red-wing	3	5	6	6	0	1
Totals	10	21	34	6	1	25

* C—control area; S—sprayed area.
** Broods brought to marsh after hatched elsewhere.

reasons mentioned in connection with the chlordane experiment; in addition, a number of nests were abandoned. Only one dead juvenile was seen on the check area although numerous birds of several species were reared there (see Table 5).

Insectivorous birds abruptly curtailed their activities after spraying as in the chlordane and DDT experiments.

The marsh was last visited six weeks after treatment at which time no occupied nests, young, or adult birds were seen on, or adjacent to, the sprayed area. The control part of the marsh had twenty-four juvenile and numerous adult ducks on it at that time, not to mention other birds.

Invertebrates.—Snails slowly declined in number following spraying until they were completely absent for about ten days. Beginning about one month after spraying their numbers started to increase. The check area, on the other hand, showed no decrease in population.

The toxaphene and oil had no apparent effect on ostracods in this experiment.

Many insects were destroyed, and no recovery was seen until August 15, a month and ten days after application of the poison. Coleoptera, Hemiptera, and Odonata were plentiful prior to spraying, but occurred in only trace amounts afterwards until recovery commenced. There was a downward trend in the control area also, but numbers never declined proportionately as they did in the sprayed area.

Plants.—It seemed that all plants contacted by the spray showed necrosis wherever a droplet of spray had touched. As time progressed, this left some of the plants looking as though they had been hit with birdshot.

The plant damage from toxaphene and oil may be summarized as follows: about 10% of the total foliage (stems in the case of spikerush) was killed; about 25% of the foliage of pale smartweed was killed; least affected genus was sedge; and, finally, few plants were killed entirely.

DISCUSSION AND CONCLUSIONS

These experiments show some of the effects of certain treatments of marsh plants and animals with 2, 4-D, chlordane, DDT, and toxaphene. Other investigations are needed to study effects of Diesel fuel alone on marsh biota, to study effects of heavier and lighter concentrations of poisons, and to test all of the chemicals mentioned on many other species of plants and animals.

The toxicity of oil to plants is well-known. Because a large acreage of land is sprayed with mixtures containing oil, damage results to wildlife habitat from this source alone.

The 2, 4-D experiments demonstrate that various monocotyledonous plants, an important group in aquatic habitats, are killed or injured. These herbicides are especially dangerous because of their long-time effects. Once the vegetation of a marsh is severely injured it may take a number of years to restore original conditions.

The somewhat greater destruction from the 2, 4-D ester spraying may have been due to either the type of 2, 4-D or the oil used with it. Crafts (1949) pointed out that the ester forms are most effective on the waxy leaves of aquatic plants, and Bohmont (1949) asserted that they are in general the most destructive to hard-to-kill plants.

These experiments seem to show that

chlordane and toxaphene, especially the latter, are damaging to young birds that swim or dabble in the water. Possibly some of the mortality was caused by imbibing poisoned water, but the actual mechanics of poisoning were not investigated. Harris (1951) has shown that spraying the body surface of pheasants with toxaphene caused death. In this case, however, few birds had hatched by spraying time. Toxaphene seemed particularly poisonous because of the way it affected birds and snails, as well as insects. Furthermore, toxaphene (chlorinated camphene) is "considerably more toxic" to fishes than DDT, according to Linduska and Surber (1948).

The effects on birds from eating insects poisoned by chlordane and toxaphene were not learned, although it appeared that DDT poisoned insects did not harm them. Harris's work (*op. cit.*) indicates, though, that insects poisoned with toxaphene are lethal to young pheasants.

It is not known why so many nests failed in the chlordane and toxaphene experiments. Perhaps part of the failure was desertion caused by the observers' intermittent presence, but some of the failure may have been due to curtailment of insect food, especially the food supply of younger birds. Even though nests on the chlordane control were likewise observed, the number of young produced per nest attempted was twice as great; the number produced per nest attempted on the toxaphene control was even greater than this when compared to its sprayed replicate.

One may conclude that the necessity of curtailing many insect and plant groups can hardly be questioned, but damage to any beneficial or harmless organisms should be avoided if possible.

Certainly the repercussions on wildlife from the present-day chemical barrage should be made clearer to the public. Otherwise, more wildlife and wildlife habitat may be destroyed in one season in various situations than can be restored in many years. A tightening of laws regulating the use of agricultural chemicals may be necessary. Perhaps the spraying threat can best be alleviated by publicizing the bad economics of spraying non-agricultural land and by advertising the general desirability of controlling weeds and insects through proper tillage and crop rotation.

SUMMARY

Five experiments with some common chemicals were conducted in North Dakota to learn more about the effects of aerial spraying on marsh wildlife and its habitat.

The two herbicides, 2, 4-D amine and water and 2, 4-D ester and oil, reacted similarly on dicotyledonous plants and produced a heavy kill. The majority of monocotyledonous species was affected, although more so in the ester and oil spraying. The only animals killed were a few insects, presumably from the oil alone.

Chlordane with water apparently interfered with bird reproduction, for only thirty-four birds were eventually produced from twenty-five nests (many at a date long after spraying). Some dead juveniles were found in spite of adverse censusing conditions. One dead muskrat was recovered although very few had been on the area. Snails and ostracods were unaffected.

The DDT and oil experiment did not yield appreciable data on juvenile birds

because none was seen on the sprayed area until the spray was almost disintegrated. Adult birds fed heavily on poisoned insects, but no harm was noticed. Salamanders were considerably reduced, and vegetation was slightly burned by the treatment.

Toxaphene and oil proved harmful to all animal life studied at the pothole except adult birds and some small crustaceans. Only six birds were known to be reared from twenty-one nests or broods. Numerous dead juveniles were found. Unlike what happened in the other experiments, snails were reduced. Few plants were killed, but the vegetation was burned wherever a droplet of spray hit.

Insects were practically eradicated for at least five weeks by all insecticides; destruction was greatest from the DDT and oil. After spraying, there were virtually no live insects left on the areas, and the birds were forced to feed elsewhere or eat the dead insects. The effects of the spraying on food of young birds must have been even more detrimental.

The public should be better educated to the effects on wildlife from large-scale spraying, and should be encouraged to control weeds and insects on cropland where possible by proper tillage and crop rotation rather than with chemicals.

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DIGESTIBILITY OF SOME NATIVE FORAGES FOR MULE DEER

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Winter forage for deer is scarce in many places throughout the West. The areas suitable for winter ranges are naturally of low productivity. Furthermore, heavy and continued use by large numbers of game animals have further reduced the forage available to them.

Rehabilitation of these ranges will be necessary if they are to support deer numbers at the highest levels obtainable. In some instances this rehabilitation may be brought about by proper management techniques, holding game numbers down until natural improvement results. In other cases it may be necessary to undertake artificial measures of plant reproduction in order to secure the desired results. In either case a more precise knowledge is desirable not only of the palatability of the forage species adaptable to an area but also of the ability of the individual plants to support the deer. It was to yield information upon the latter point that several digestion trials were planned with mule deer (*Odocoileus hemionus*). The results secured from sagebrush (*Artemisia tridentata*) have been reported (Smith 1950). Herein are contained the data secured from trials using other species.

[1] The work reported herein was conducted under the cooperative research program on game-livestock competition. At the time the work was done the author was Associate Project Leader, Federal Aid, with the Utah State Fish and Game Commission.

Procedures

The trials were conducted during the winter of 1948-49 and 1950-51. Three native species were tested. The plants were collected from the range and brought to the feeding site where the foliage and current growth of twigs was removed by hand clipping. This proved to be a formidable task, especially in the case of bitterbrush (*Purshia tridentata*), but it was believed to be desirable in order to secure accurate records and insure adequate forage intakes. Curl leaf mahogany (*Cercocarpus ledifolius*) and juniper (*Juniperus utahensis*) were more easily handled.

In addition to the above species, tests were conducted upon alfalfa hay. Since it was believed that comparisons of the digestion values secured from mule deer with those published in feeding tables for domestic livestock might be hazardous due to the differences in the composition of alfalfa hay used, two sheep were tested with the same feed.

The deer were confined in crates previously described (Smith 1950). The sheep were held in conventional crates designed by the animal husbandry department.

All animals were fed in the crates for a preliminary period of from five to seven days before collections were begun, the period depending upon the feed consumed prior to initiating the

trials, and the reaction of the animals to confinement. The actual collection period was ten days except in the instance of bitterbrush when but seven days' collections were made, in consequence of the great difficulty encountered in securing forage from this species.

RESULTS

Except for those animals fed juniper, little difficulty was experienced in completing the trials. After a few days in the crates the animals proceeded to eat fairly well, although some animals did not eat large amounts even of an apparently palatable species such as curl leaf mahogany, one deer consuming but a little more than one pound per hundred weight of this species daily.

The data on consumption during the period of the test and body weight changes are summarized in Table 1. These weight changes are only for the seven to ten days during which collections were made. In all cases there was a loss of weight when the animals were first confined. It may be noted that of four deer fed alfalfa hay three gained weight during the period of record. While being fed bitterbrush, two showed slight gains, although the period was in this instance but seven days rather than ten.

Only two deer were successfully carried through the ten-day period on juniper. Although four were used initially, two threatened to die due to an extremely low forage intake and they were removed from the crates. The mature male upon which a test was completed consumed much less than he had on any previous test. In contrast, the short yearling buck consumed even more than he had of mountain mahogany.

The digestibility coefficients are shown in Table 2, together with the digestible nutrient values based upon air-dry weight. Juniper is based upon but two tests which is unquestionably too few but circumstances prevented securing additional tests upon this species. Based upon these two tests it would appear that the limited protein

TABLE 1.—ANIMALS USED IN DIGESTION TESTS WITH TOTAL WEIGHT CHANGES AND AVERAGE DAILY CONSUMPTION

Animals	Age at time of test and sex	Curl Leaf Mahogany		Bitterbrush		Juniper		Alfalfa leaves	
		Weight changes lbs.	Consumption lbs./cwt.	Weight changes lbs.	Consumption lbs./cwt.	Weight changes lbs.	Consumption lbs./cwt.	Weight changes lbs.	Consumption lbs./cwt.
Deer									
1	3 M	−5.0	2.03			−2.3	0.86	−3.0	1.89
2	3 M	−3.0	1.76						
3	2 F*	−4.0	1.51	+0.5	1.83			+1.0	1.96
4	3 M	−7.5	1.10					−2.5	2.42
5	1 M	−8.0	1.56			−4.3	2.01	+2.5	2.98
6	2 F			0	1.74				
7	3 F			+1.0	1.84				
8	2 F			−2.0	1.86				
Sheep									
1	1 M							+1.0	2.93
2	1 F							+4.0	2.98

* Deer 3 was 4 years old during the test on bitterbrush.

present together with the high fat content make juniper a very poor feed especially for young animals.

From the standpoint of proper balance between nitrogeneous and non-nitrogenous material, curl leaf mahogany has the best nutritive ratio of the native forages tested, showing a value of 10.3. Even this is excessive when compared to feeding standards for young domestic livestock. It is possible, however, that current methods of calculating nutrient values are ill adapted to native feeds with large amounts of essential oils.

As compared to the other two native species, bitterbrush provided the least total digestible nutrients. This may be due to the limited amount of foliage present in winter, for at this season stems make up the bulk of the material available.

The data regarding alfalfa hay are of particular interest in view of the fact that winter feeding tests have indicated that it was not an adequate maintenance feed for deer. The digestibility coefficients appear not to differ significantly between the sheep and the deer, except in the cases of ether extract and possibly crude fiber. In these cases the values secured from the deer tests were lower and higher respectively than in the case of sheep. In consequence, however, of the low ether extract content of alfalfa, there is little difference in its apparent nutritive value for sheep and deer. The results secured indicate that sheep might be expected to extract 62.2 pounds and deer 64.7 pounds of digestible nutrients from 100 pounds of the material. This slight difference may have been due to the fact that deer were somewhat more fastidious in sorting out the stemmy material that passed the screen. The results secured both for deer and sheep are close to values reported in feeding data (Morrison 1947). It would thus appear that the answer to failure of deer satisfactorily to subsist on alfalfa hay is not attributable to lack of ability of the animals to utilize the feed ingested although it should be

TABLE 2.—AVERAGE DIGESTIBILITY OF FORAGES FOR MULE DEER

		Mountain Mahogany	Juniper	Bitter-brush	Alfalfa deer	Alfalfa sheep
Protein	Composition	10.6	5.9	7.4	18.7	
	Percent Digestible	54.3	10.2	35.7	76.9	74.6
	Dig. Nutrients per 100 lbs.	5.8	0.6	2.6	14.4	13.9
Ether Extract	Composition	9.1	11.8	5.4	2.7	
	Percent Digestible	42.9	54.0	53.0	17.0	45.5
	Dig. Nutrients per 100 lbs.	3.9	6.4	2.9	0.5	1.2
Crude Fiber	Composition	18.0	23.8	30.6	23.0	
	Percent Digestible	35.9	29.6	18.3	48.9	41.2
	Dig. Nutrients per 100 lbs.	6.5	7.0	5.6	11.3	9.5
Nitrogen-free Extract	Composition	58.2	54.2	53.6	45.9	
	Percent Digestible	76.3	66.5	57.3	82.9	78.5
	Dig. Nutrients per 100 lbs.	44.4	36.0	30.6	38.0	36.0
Total Digestible per 100 lbs. Nutrients		65.4	58.0	45.4	64.7	62.2
Nutrient Ratio		10.3	95.7	16.5	3.5	3.5

noted that the immature animal (No. 5) performed less well than did the older deer.

From the results secured here and observations made on sites where deer have been fed, the answer to the inadequacy of alfalfa hay must be attributed to causes other than nutrient value. The material fed in this case was largely leaves. The baled hay available was screened to eliminate most of the stemmy matter, which from prior observations deer would not eat. The problem of securing an adequate forage intake was thus solved. The material passing through the screen which was offered to the animals, both deer and sheep, was 46 percent of the original weight. Moreover, not all of this screened material was eaten by the deer, 28 percent of all the material placed in the feed boxes being uneaten stems which had passed through the screens. Thus about 25 percent of the original weight of the hay was actually consumed by the animals. Even were deer fed alfalfa hay successfully, it would be an extremely wasteful process. Moreover, it is questionable if deer could be expected to recover the leaves as efficiently on the feed ground as was possible through the procedures used in these tests.

SUMMARY

Three native plants important on winter deer ranges were used in standard digestion trials using mule deer as the subject animal. Curl leaf mahogany appeared to be better than bitterbrush and juniper poorest of the three, considering both amount and the character of the digestible nutrients.

Alfalfa hay leaves appeared of about equal value to deer and sheep, but deer rejected somewhat more of the stemmy material than did the sheep.

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THE AGE AT SEXUAL MATURITY IN MALE ELK (*CERVUS CANADENSIS*)

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The age at which the male elk becomes sexually mature has not been known. Reports in the literature are based upon instances of observed copulations rather than upon testicular anatomy. In these observations of breeding activity there is considerable disagreement as the following statements indicate. West (1941) says "bulls usually do not become of breeding age until they are 3½ years of age." However in the same paper he reports that in 1935 yearling bulls were observed breeding in the Gallatin National Forest. Green (1933) states that "2 or 3-year olds, although desirous and capable of performing the sex act, stand little chance in open competition with their elders." Murie (1951) records an observation of a yearling male breeding but concludes that, "On the whole although spike bulls occasionally may be found somewhat active sexually they are not so normally."

The present study is concerned with the age at which spermatogenesis occurs in the elk rather than the age at which breeding begins. It is of interest to know the age at sexual maturity so that the significance of observed reports of copulation may be better understood.

Methods

During the big game hunting seasons of 1947 through 1950, both testes and the complete head or toothrows were obtained from a number of hunter-killed elk in western Montana. Those animals killed prior to December were taken from the Bitterroot Mountains or the South Fork of the Flathead River Primitive Area. All December specimens were killed during the special season in which elk from the North Yellowstone Park herd are hunted in the vicinity of Gardiner, Montana.

Much of the material was collected for the author by interested hunters, chiefly members of the staff of Montana State University or Montana State Game and Fish Commission. Because large numbers of elk are killed in relatively restricted areas it was possible to collect material directly from hunters in the Gardiner region during the special season in December of 1947 and 1948.

Both testes and attached epididymides from each individual were preserved in Mossman's modification of A.F.A. fixative (Guyer 1940) as soon after the animal's death as possible. A small slit was made through the tunica albuginea to facilitate fixation.

After fixation the epididymis was removed from each testis and all loose connective tissue was cleaned from the tunica albuginea. The material was then stored in fresh fixative for several months or more. After this one testis was removed from the fixative, rolled briefly on a paper towel to absorb excess fixative, then weighed on a balance accurate to 0.1 gm. The volume of the

testis was next measured by placing it in a partially filled graduated cylinder and measuring water displacement. A portion of the testis and the cauda epididymis from each animal was sectioned at 10-14 micra. Sections were stained with iron hematoxylin or Erhlich's hematoxylin and eosin.

The age of the elk was determined by following the method described by Murie (1951) which is based upon toothwear and tooth succession.

Results

Table 1 summarizes the data for all age classes and individuals which are discussed.

Calf. The testis of the single calf examined is immature and without evidence of spermatogenesis. The seminiferous tubules contain only Sertoli cells and spermatogonia. No lumina are present. The epididymal epithelium is low columnar. Testes from several other calves were examined grossly and these were similar in size to the specimen described.

Yearling. Spermatogenic activity is apparent in all specimens of this age class. The testes of animals taken from September through November 5 are in active spermatogenesis. Lumina of the semeniferous tubules contain sperm and noncellular material. Primary and secondary spermatocytes are abundant. The epididymides are well developed and their tubules have large lumina containing abundant sperm.

Regressive changes are visible in the testes of two specimens killed on November 14 and 15. In each many tubules are similar to those described as active.

TABLE 1.—TESTICULAR CONDITION OF MALE ELK

Date	Testis		Condition of semeniferous tubules	Condition of epididymal tubules
	wt. grams	vol. c.c.		
	Calf			
Dec. 30	3.6	3	immature—no spermatogenesis	undeveloped—no sperm
	Yearling			
Sept. 17	30.5	30	active spermatogenesis	well developed—abundant sperm
Sept. 17	34.0	32	" "	" " " "
Oct. 20	35.2	34	" "	" " " "
Nov. 5	35.5	31	" "	" " " "
Nov. 14	32.5	33	active—regression in some tubules	" " " "
Nov. 15	32.0	30	" " " " "	" " " "
Dec. 15	25.0	23	" " " " "	" " " "
Dec. 15	28.8	28	" " " " "	" " " "
Dec. 17	25.3	21	regressed—no spermatogenesis	well developed—few sperm
Dec. 26	24.4	23	active—regression in many tubules	" " —abundant sperm
Dec. 29	22.9	22	active—regression in some tubules	" " " "
Dec. 29	26.0	24	active—regression in many tubules	" " " "
	2½ year old			
Dec. 28	32.8	32	active—regression in some tubules	well developed—abundant sperm
	Adult			
Sept. 15	..*	..*	active spermatogenesis	well developed—abundant sperm
Oct. 15	76.0	77	" "	" " " "

* Data not recorded.

In other tubules there is a reduction in later spermatogenic stages with vacuolization of cells. The epididymides of both specimens contain abundant sperm. No degeneration of the epididymal epithelium is apparent.

Varying degrees of regression are seen in the testes from all December killed elk. In the specimen killed December 17 spermatogenesis has ceased. All tubules have large empty lumina with a single basal layer of epithelium showing extensive vacuolization. Sperm are almost absent from the epididymis although the tubules are large and have a normal epithelium. The remainder of the December specimens have both active and regressed tubules. The epididymides contain sperm.

It may be seen from Table 1 that a decline in weight and volume follows the regressive trend of the testes as seen in microscopical sections.

Older. The testes of a 2½ year old male and two older animals of undetermined age were examined histologically. Testes of adult males most of which were not examined in detail were noted to be considerably larger than those of the yearling animals. The few which were examined were similar to the yearling animals in the diameter and condition of the semeniferous and epididymal tubules.

Discussion. From the material examined it is apparent that the yearling male elk is sexually mature since all specimens examined showed spermatogenic activity and abundant sperm in the epididymis. The time at which spermatogenesis begins cannot be determined from the material examined.

There seems no cause to doubt that the yearling male elk would be fully capable of making fertile matings. In the absence of actual breeding tests the presence of abundant sperm in the tail of the epididymis is the best indirect evidence of fertility. Whether copulation accompanies sexual maturity, and to what extent if it does, can only be determined by careful field observation. It seems highly probable that the greater physical vigor of older males would restrict breeding activity in the younger age classes as Green (*op. cit.*) indicates. It might be expected that in herds in which the number of adult bulls is greatly reduced, the younger classes would be more prominent in breeding.

ACKNOWLEDGEMENTS

I am indebted to Dr. Philip Wright for many helpful suggestions concerning this problem. The cooperation of the Montana State Fish and Game Commission made it possible to collect material in the Gardiner area during 1947 and 1948.

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MECHANICAL AIDS USEFUL IN STUDYING BOBWHITE QUAIL[1]

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One phase of a Pittman-Robertson bobwhite quail (*Colinus virginianus*) investigation, conducted in southern Indiana, was a live-trapping program. During the five years of quail trapping, 1946-1950, several devices and techniques were developed. Supervising personnel, as well as the writer, believe the following developments may be of use to other wildlifers. With that thought in mind, the devices are described. Some of the ideas are not original, but the variations or changes are thought to be improvements over previously described techniques.

Banding Cage

A major problem encountered in trapping live quail is the removal of birds from the trap. One solution is the use of a small wire cage about 5 x 12 x 20 inches. Bobwhites can be driven from the trap into the cage with the least possible excitement. With birds confined in a small area, there is a minimum of movement and, consequently, little chance for injury. The same cage is equally useful in banding and releasing quail.

The cage is constructed of ½-inch mesh hardware cloth. The top, bottom, and sides are made of one piece. The back end is laced to the body with small diameter wire (preferrably 20-gauge copper wire). A partition, 5½ x 11 inches, is hinged from the top, providing 2 compartments about 5 x 10 x 12 inches. A doorway, 5 x 5 inches, is cut into each compartment. The rear door is on the right side adjacent to the back of the cage. The door in the front compartment is in the end near the right side. The front end is hinged at the bottom and can also be used as a door when releasing birds. A wire handle, placed in the center of the right side, makes the cage easily carried. The doors are also built of hardware cloth and can be opened by sliding them upward through metal grooves, which are connected to the edges of the doorway.

A precaution that should be used when working with hardware cloth in traps is to cut wires midway between parallel wires; then bend each of the projecting wire ends around the last parallel wire, thus preventing it from being unraveled. Care should be taken to avoid breaking the solder joints.

The use of a banding cage permits a trapper to follow a mass production procedure of banding, processing, and releasing quail. After bobwhites are driven from the trap into the cage, and maneuvered into the rear compartment, the partition is closed and the cage covered to quiet the birds. The trapper faces the right side of the cage.

[1] A contribution from Pittman-Robertson Wildlife Research Project 2-R, Indiana Department of Conservation, Division of Fish and Game.

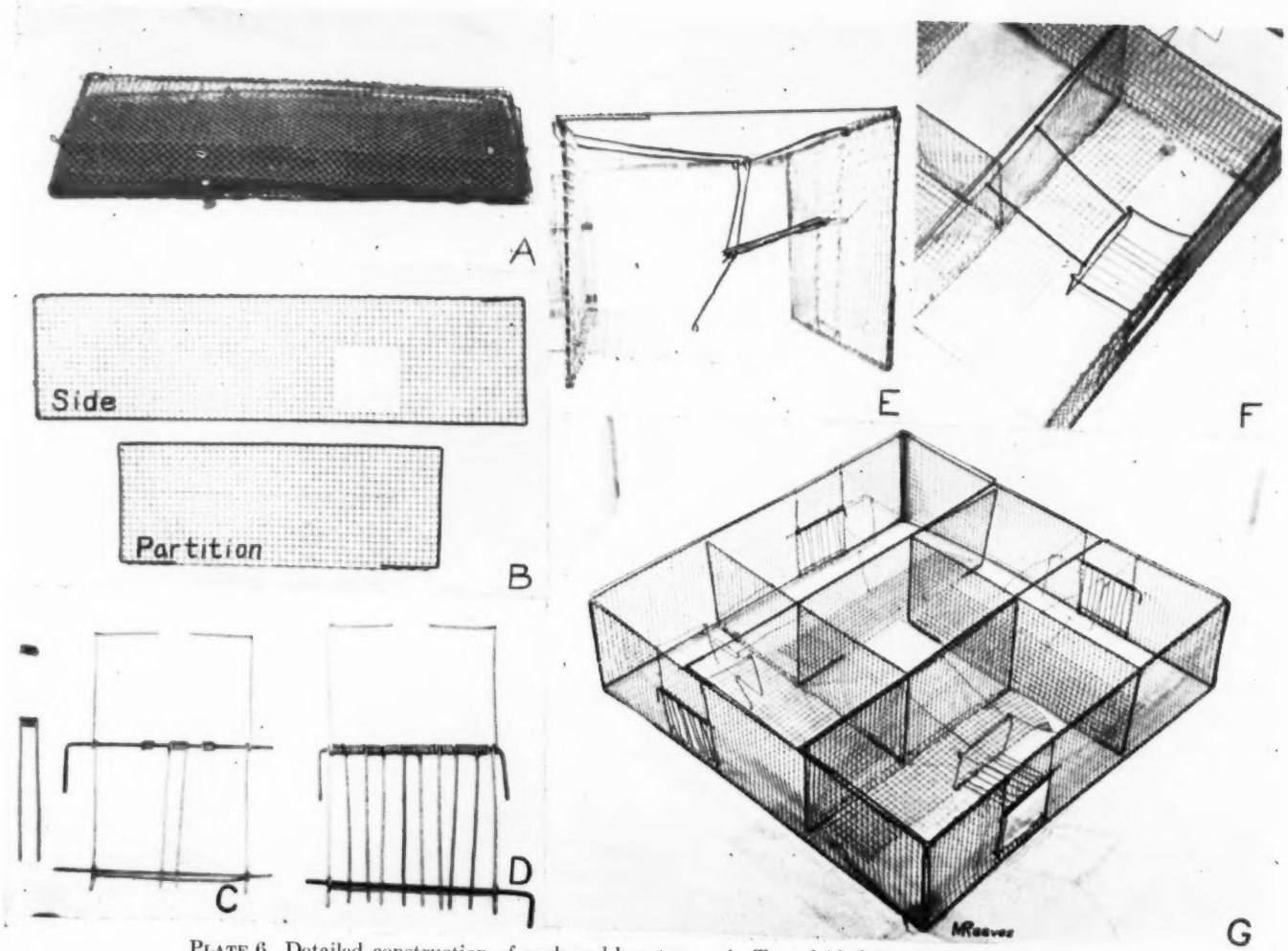

PLATE 6. Detailed construction of cock-and-hen trap. A. Trap folded for carrying or storage. B. Side and partition. C. Close-up view of door segments. D. Door and frame showing arrangement of segments and spacers, with door locked. E. Side view of tripping device, showing opened door supported by cradle. F. Top view of tripping device, showing cradle connected to treadle. G. Assembled sides, doors, and partitions, showing arrangements of compartments.

He removes a quail from the rear compartment with his left hand, and closes the door with his right. After a band is applied, the quail is inserted head first into the weighing bag and the trapper examines the bird to determine its sex, age, and condition. After being weighed, the bird is caught in the right hand and placed in the front compartment of the cage. When all quail are processed, the cage is covered and carried to a clearing, where it is placed on the ground. The trapper then opens the front end and backs away, allowing the bobwhites to escape as a covey. Usually all birds follow the first one to take flight.

A convenient device for weighing live birds in the field is a light weight Nylon crepe bag about 7 or 8 inches square with a drawstring around the top. Quail seldom move while in the bag suspended from the scales.

COLLAPSIBLE COCK-AND-HEN TRAP

The improved design trap uses the principle of attracting cocks by having a hen as a decoy, as described by Stoddard (1931). However, it differs in size and design. The size of the trap is patterned after a collapsible type designed by R. A. Pearce in 1948, and described in an unpublished paper. New type doors and tripping devices allow the entry of additional quail after a door has been closed by the first bird caught. A lightweight frame permits the trap to be folded into a compact bundle, about 3 x 12 x 36 inches, weighing slightly less than 10 pounds (Plate 6).

The overall dimensions of the trap are 9 x 36 x 36 inches. It is divided into 4 exterior compartments, 9 x 12 x 24 inches, which surround an interior decoy compartment, 9 x 12 x 12 inches. The sides and partitions consist of $\frac{1}{8}$-inch cold-finished steel rod framework covered by $\frac{1}{2}$-inch mesh hardware cloth. The door segments are made of 10-gauge galvanized wire bent into hairpin spring shapes. Each door is made up of 5 segments separated by coiled wire spacers supported in a wire frame. The door is held open by a wire cradle which supports the ends of the door segments. The cradle is connected by a small wire to a hardware cloth treadle which is hinged near the bottom of the inside partition. When the treadle is tripped, the cradle is pulled forward allowing the door to close. With the doors closed, bobwhites can and do push their way into the trap, but are unable to get out.

The framework for the top consists of three, 12 x 36 inch rectangles of steel rod hinged together by copper wire. The end of one partition is hinged to the middle of the second, then the upper edge of the first is hinged to one side of the inside top frame. The other two partitions are connected in a similar manner and hinged to the opposite side of the center top frame. When the partitions are turned at right angles to each other, they form the decoy compartment of the trap. The sides are then placed around the top frame and two opposite corners wired loosely together. Next the outer top frames are hinged to the upper edges of the adjoining sides. After the sides and partitions are connected to the top frame, the top is covered by lacing a $\frac{1}{2}$-inch mesh cotton netting to the outer edges.

Materials needed for one trap are: four, $\frac{1}{2}$-inch mesh hardware cloth sides,

B. Side and partition. C. Close-up view of door segments. D. Door and frame showing arrangement of segments and spacers, with door locked. E. Side view of tripping device, showing opened door supported by cradle. F. Top view of tripping device, showing cradle connected to treadle. G. Assembled sides, doors, and partitions, showing arrangements of compartments.

10 x 37½ inches; four partitions of the same material, 10 x 25 inches; four, 9 x 36 inches, rectangular frames of ⅛-inch steel rod; four, ⅛-inch frames, 9 x 24 inches; four hardware cloth treadles, 4½ x 22 inches; one piece of ½-inch mesh cotton netting, 36 x 36 inches; three frames, 12 x 36 inches; 32 feet of 10-gauge galvanized wire; 20 feet of 20-gauge copper wire; and about 25 feet of 21-gauge cotton seine twine.

IMPROVED COVEY TRAP

Many types of covey traps have been constructed by poachers and game managers (Reeves 1950), but probably the most widely used by technicians is the Stoddard Standard Trap or some variation of it. Traps, which do not provide some sort of protection against scalping, are of little use in live-trapping.

By reducing the size of the Stoddard trap from 36 x 36 to 30 x 36 inches, it is made much easier to carry in the field, and does not change its effectiveness. The use of ½-inch mesh netting to prevent scalping excels one inch mesh by lasting longer and eliminating injury due to birds becoming entangled in netting cut by rabbits or other intruders. Camouflage painting, according to army standards, increases the take of quail, especially in warm, clear weather.

A large semi-conical shaped entrance also proves more effective than a smaller, tunnel-like opening. A funnel-shaped entrance about 15 inches wide and 9 inches high, which extends into the trap about 12 inches, narrowing to an opening 3 inches wide and 4 inches high, proved superior to other types. The funnel, made of ½-inch mesh hardware cloth, prevents quail from escaping and excludes rabbits much better than the tunnel-like entrance (Reeves 1948).

SLIDE RULE FOR DETERMINING THE AGE OF QUAIL

The figures on an inexpensive slide rule can be removed to provide the blank for a quail-aging rule. The back side can also be utilized with a detailed table, showing quail ages by weekly periods, as determined by the loss of primary feathers during the post-juvenile molt (Petrides and Nestler, 1943). The purpose of the device is to speed up the process of determining the age of quail (Thompson and Taber, 1948), and to calculate the hatching date of the bird.

The upper scale "A" of the rule is graduated to show the age in weeks (Figure 1), as determined by the growth of the newest primary wing feather. Scale "B" is graduated in millimeters or could be in fractions of total wing feather length. To ascertain the age of a juvenile quail, the length of the newest primary wing feather is measured in millimeters, then the corresponding number on the "B" scale is placed opposite the "length of feather indicator" on the "A" scale. The "age in weeks indicator" on scale "B" points to the age of the bird as shown on scale "A." For example, if the 8th feather measures 30 mm., the bobwhite is 16 weeks of age.

The lower scale "D" is divided into weekly periods running from spring to the last day of the hunting season. Scale "C" is also graduated in weekly periods from 0 to 21. To determine the hatching date of a known aged bird, the weekly age on "C" is set opposite

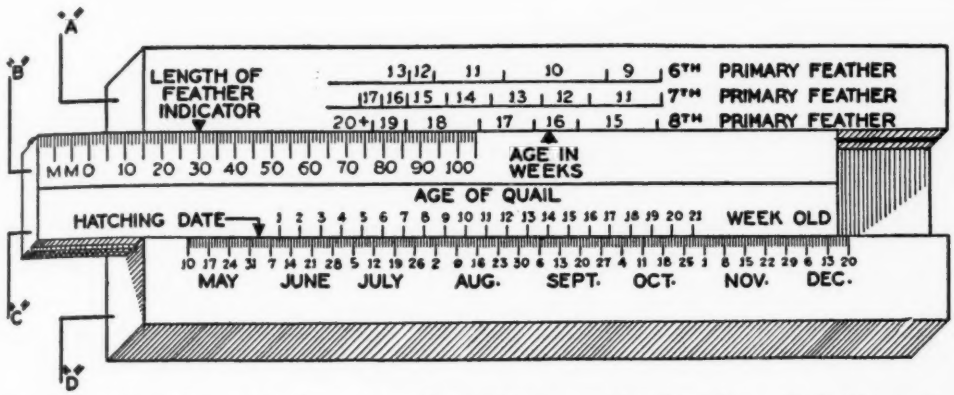

FIG. 1. A slide rule useful in determining the weekly age and hatching date of bobwhite quail.

the date collected on "D", and the hatching date is shown on "D" opposite 0 weeks or the hatching date indicator. For example, a 20-week old quail killed on October 21, was hatched on June 3.

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THE USE OF AERIAL PHOTOGRAPHS AND ECOLOGICAL PRINCIPLES IN COVER TYPE MAPPING[1]

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Introduction

From four years of experience in the field it is evident to the writers that many wildlife biologists are unaware of the extent to which ecological principles can be applied in the interpretation of aerial photographs used for cover mapping. Acquired knowledge and technique in the use of photographic interpretation, comparable to the development of mapping in the field of forestry, does not yet exist in wildlife management. In fact, as indicated by recent methods, the forester is more rapidly approaching the use of certain ecological principles, of value to the wildlife profession in forested areas, than is the wildlife biologist himself.

Wilson (1920) combined the use of aerial photographs and maps in delineating forest types from the air. In 1932 Moir mentioned the stereoscope as an aid in making contour maps, determining tree heights, and identifying tree species. Lee (1941) stated that controlled aerial photographs are unequalled in defining the exact shape, size, and location of areas. His work, though applied to fuel type mapping, is a significant contribution to the application of ecological principles in cover mapping.

The use of infra-red film (Spurr, 1948) has facilitated identification of differences in vegetation through recognition of moist sites, which appear as dark color tones on aerial photographs.

The Northeastern Forest Experiment Station (1949) has developed, to a high degree, extensive type mapping of forest cover. The method consists of entering, on the photographs, code numbers of forest types observed along routes of travel. Particular attention is given to the distribution of forest types in relation to topography. The maps are completed in the office. Using topographic and cultural features as a guide the type boundaries are delineated on U.S.G.S. topographic maps. A stereoscopic study of the photographs is made throughout the delineation.

In the development of photo interpretation as applied to cover mapping the forester has shown increasing technical skill thus far culminating in such methods as radial line plotting; classification of cover types which are essentially *a priori* in nature; and recognition of the ecological principles involved in differences of vegetation as instanced in the use of infra-red film and cognizance of the relationship between forest type and topography.

[1] Contribution from Pittman - Robertson Project 21-R. The writers wish to acknowledge the kind and helpful advice given by Dr. Warren W. Chase, School of Natural Resources, University of Michigan; Carl Burgtorf, District Ranger, Monongahela National Forest; Dr. Earl L. Core, Head, Department of Biology, West Virginia University; C. O. Handley, Chief, Game Division, Conservation Commission of West Virginia; and R. D. Van Deusen, Biologist in Charge, Natural Resources Inventory, Maryland.

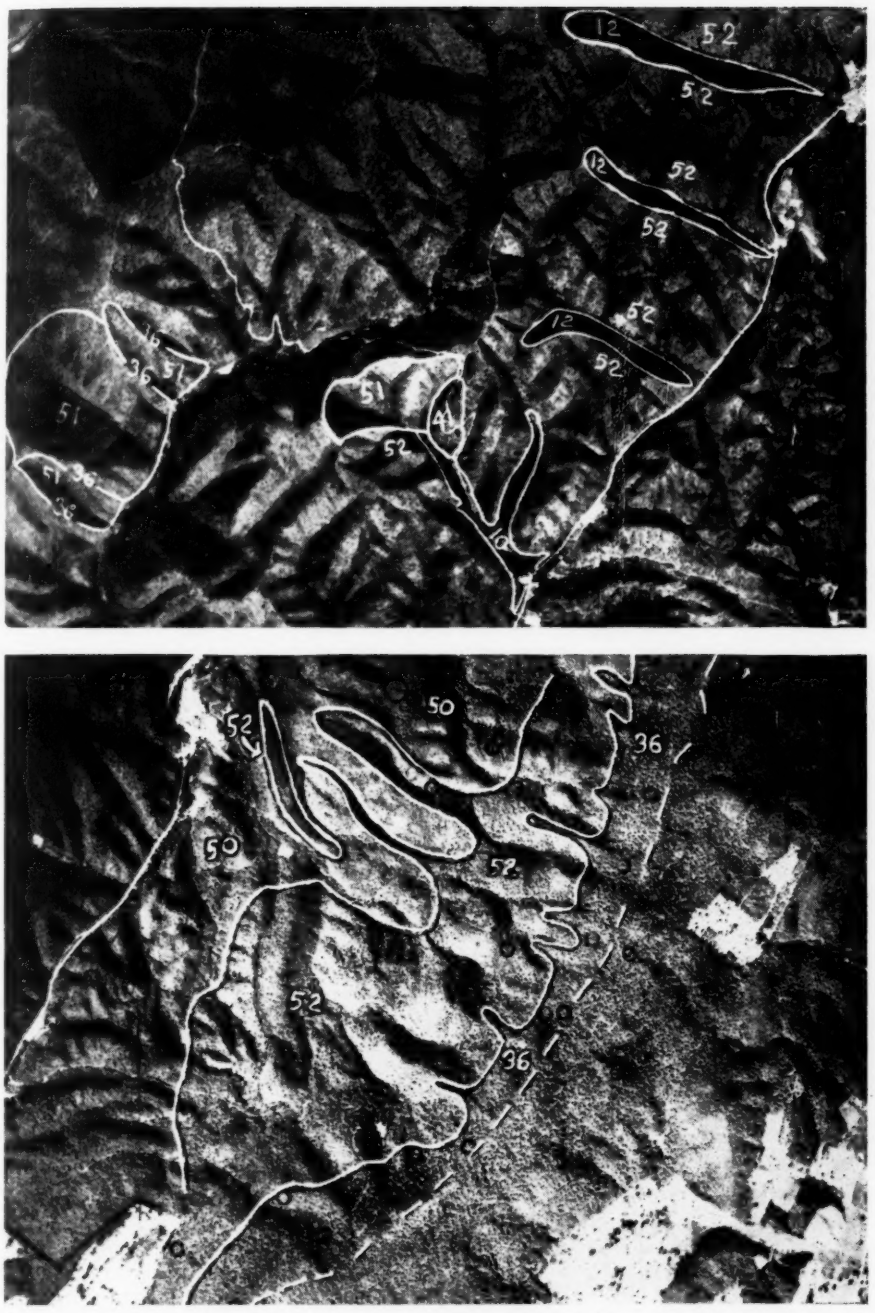

PLATE 7. Upper. Alternes of chestnut oak forest type on ridges and oak-hickory forest type in hollows; oak-hickory forest type at head of hollow having other types below; and northern hardwoods on north slopes. Lower. Alternes of the red oak and the white oak forest types and zonation of the white oak, red oak, and chestnut oak forest types on Clymer stony loam. Code number 10 indicates conifers; 12, northern hardwoods; 36, chestnut oak forest type; 41, hard pine-oak forest type; 50, white oak forest type; 52, red oak forest type; dashed line, a ridge; small circle, a sample plot; and large circle, a principal or conjugate principal point.

Dalke (1937) and Leedy (1948) have made notable contributions to the development of wildlife cover mapping through photo interpretation. Dalke used mosaic prints nineteen by twenty-five inches in size. On the aerial photographs he delineated such things as coniferous and hardwood stands, stone walls, fences, and other features. Such delineation is of course important to the understanding of local plant ecology. However, this is overshadowed by his identification of seepage areas and periodic swamps. These are characterized by growths of shrubs, herbaceous plants, or light mixtures of trees distinguishable, on the photographs, from surrounding vegetation. This is significant in that it denotes recognition of an ecological principle, namely differences in vegetation caused by water content of the soil. A mapper unaware of these relationships could easily fail to recognize such areas on the photographs especially if they be surrounded by woodland. Dalke does not mention the stereoscope although it was in use at that time.

Leedy (1948) summarized the many advantages of aerial photographs and instruments and how to use them. He describes differences in photo texture and color tone by means of which zonation of vegetation, such as grass and brush bordering a forest, can be identified. He recognizes the value of obvious patterns such as those exhibited by plantations, orchards, and meandering streams with their accompanying vegetation. However, a variety of less obvious vegetative patterns can be identified and used to advantage in wildlife cover mapping.

The writers propose to show how, through knowledge of ecological principles in conjunction with the use of aerial photographs, certain repetitive patterns of vegetation can be established which are adaptable to efficient and informative mapping of forest cover in mountainous terrain.

METHODS

Office

Vertical aerial photographs are used. These can be ordered through the Office of Plant and Operations, U. S. Department of Agriculture; the U. S. Geological Survey; and the Soil Conservation Service. The latter agency is making increasing use of photographs larger than the preferred size. It is desirable that these photographs be of the nine by nine inch size as they may then be conveniently carried in a clip board. The photographs should be those taken at an altitude showing features in sufficient detail for photographic interpretation. Camp and Caporaso (1950) recommend photos taken at a scale of 1:15,840. Photos with a scale of 1:20,000 are adequate but not so highly regarded as the former.

Using stereoscopic examination, the desired features are outlined on the photographs. The delineation includes roads, trails, buildings and other structures, property boundaries, stand-size classes of timber, watersheds, streams, and water bodies. As an aid in accurate delineation of property, blueprinted plats are used in transferring property lines to topographic maps of the same scale. Property lines may then be located on the photographs in reference to topographic features on the maps. Dixon Phano pencils for glazed surfaces have been found useful in feature-deline-

ation. The No. 73 yellow, No. 71 red, and No. 81 blue pencils should suffice for most purposes. The pencil marks do no damage to the photo emulsion and can be easily erased with art gum.

Vegetation of differing size often varies in abundance and distribution of food and cover. Photographic interpretation of stand-size is advantageous in locating such vegetation. Camp and Caporaso suggest a quick approach through recognition of crown classes. It is advisable to use the stereoscope when delineating crown classes. Using visual examination alone, the photo interpreter will often experience difficulty in determining the size of crowns on the shaded sides of ridges.

Radial line triangulation is utilized in constructing the base map on tracing paper. Two copies are made, one as a control map and the other for use in constructing the type map.

Selection of sample plots in the number desired for quantitative analysis of the vegetation should follow delineation of features. The sample plots are selected by means of a grid and table of random numbers.

On the control map watersheds, soil types, check lines, and sample plots are delineated and designated by code numbers. This map is an aid in the planning and execution of field work. It is a convenient source of reference when entering drainage basin, soil type, and plot number on tally sheets used in the field work. The control map also facilitates selection of check lines and can be used as a progress check simply by coloring in the plots and cross-hatching sections of the map which have been completed.

In order to map areas not covered during the sampling, check lines are laid out on the photographs in such a manner as to get an adequate cross section of the vegetation. In mountainous country, these check lines can be planned to facilitate the easiest return route for the mappers.

Before beginning field work, the photo scale should be calculated (Rogers, 1948) and the tally sheets prepared. All pertinent information from the control map should be entered on the tally sheets. This serves the mapper with useful advance knowledge and saves him the trouble of entering the information on the tally sheets at a later time. Small sketch maps showing plots, starting point, compass bearings, and distances to the plots are of value when prepared for each day's work and carried in the clip board with the tally sheets and photographs.

Field

Field work consists of type mapping and sampling in parties of two. The first step in mapping consists of a reconnaissance in which roads and major trails are travelled and the forest type and species and density of edge vegetation recorded by code number on the photographs. Dixon Phano pencils are used throughout the typing. The code numbers as applied by the Northeastern Forest Experiment Station (1949) to forest types or group names have proven to be quite useful. Additional type codes are added when necessary.

In travelling to the plots, a bearing is first established on the photograph. This is done either by taking a compass shot along a straight piece of road or between two points easily discerned on the photograph. The bearing to the plot is then

determined either by drawing a north line or by turning off an angle in reference to the established bearing. The distance from the starting point to the plot is measured, and the mapping party is then ready to take the plot. One man runs the compass line and pulls the surveyor's chain, while the other tallies the distance to the plot and does the typing. The type line and code number are entered on the photographs. Frequent use is made of the stereoscope (refraction type) in determining the actual location of type lines in relation to the terrain. Springs, unusual concentrations of food or cover plants, and observations of wildlife are also recorded on the photos. Mapping is done on the check lines at the mapper's convenience.

While in the field, it is essential that the mapper actually delineate the types in addition to entering the proper code numbers. Otherwise, he may find himself hopelessly confused by a jumble of unseparated code numbers.

Utilizing knowledge of the differences in the development and structure of vegetation, the mapper can adapt the use of aerial photographs to intensive mapping of mountainous areas and to a somewhat lesser degree to terrain less rugged in character.

Frequent more or less striking differences are typical of most vegetation. Where there is an abrupt change in conditions on either side of a ridge, vegetation exhibits *alternes*, or a sudden rather than a gradual change in vegetation. Thus, a series of parallel ridges trending east and west may have birch-beech-maple on the moist north slopes and scarlet oak-black oak on the dry south slopes. After sufficient mapping has been done, this repetitive pattern of vegetation will have become apparent (Plate 7). Having crossed two or three of the parallel ridges and having established the pattern, the mapper can then, without further travel, delineate the types on the remaining ridges.

Distinct patterns are often apparent at the head or upper end of hollows and along ridge tops. In the Allegheny Mountains, for example, oak-hickory is often found at the head of hollows, while mixtures of hard pine and chestnut oak might occur on dry ridge tops (Plate 7, Upper). The differences are probably edaphic. The mapper will also distinguish a pattern composed of vegetation in the upper end of hollows as distinct from that in the hollows themselves. Differences in photo texture are useful in distinguishing zonation of grass and brush on the forest edge.

Rock structure, slope, soil type, and soil depth are influential in the development and structure of vegetation. In the Allegheny Ridges and Valleys Subdivision of the Appalachian Physiographic Province, for example, the deeper Clymer stony loam on the gentle lower slopes of anticlines supports a growth of white oak and hickory as distinct from zones of red oak and chestnut oak as one progresses from lower slopes to the dry shallow Clymer stony loam on the ridge tops (Plate 7, Lower). So pronounced is the related change in topography, as shown on the photographs, that the mapper will have no difficulty in drawing the type lines. Only occasional ground checks of the actual type lines are necessary.

When mapping mountainous terrain in which one or two cover types predominate, the photographs should be

carefully examined for steep coves on north slopes. Such locations usually support vegetation adapted to moist conditions. Wildlife biologists, to whom the interspersion of vegetation is important, should be on the alert to the possible occurrence of such cover types. Similarly, roadsides can be mapped on the basis of dry and moist site vegetation in relation to aspect or direction of slope. Knowledge of cover types gained in the field will aid the mapper in knowing which species occupy dominant positions in roadside vegetation on various sites. His typing will then be primarily concerned with density.

MAP CONSTRUCTION

The cover types delineated on the photographs are entered on the base map daily. This map is then inked and blueprinted to the desired scale. Next, a careful tracing is made of the blueprinted map and any necessary refinements in drawing are added.

Following analysis of plot data, the cover types are symbolically expressed on the map. The value of the complete map can be considerably increased by including three small inset maps showing soil types, drainage basins, and topography. The legend can also be expanded to include brief soil descriptions, climatological data, and a breakdown of cover types by species and their abundance-distribution ratings (Webb, 1942) for the entire area. Graham's classification is adaptable to a map containing such information. In using his classification, the authors recognize the concept of the layered forest. Those species which are most abundant and widely distributed are included in the basic type formula which is expressed as:

Successional Stage	saw-timber sapling shrub or vine	saw-timber sapling shrub or vine	(pole-timber) large herb	(pole-timber) shrub herb

In the interests of spatial requirements herbaceous plants are included on the same line with shrubs and vines. Graham's density symbols are used to represent abundance-distribution classes. Other recommended symbols, for ecological factors not otherwise incorporated in the map, are employed in the formulas.

COSTS

Using the line-plot method without aerial photographs, four months were required in which to map the 8,878 acres of Short Mountain Game Refuge, Hampshire County, West Virginia. Employing aerial photographs, random sampling, and pattern mapping, only two months were spent in mapping the 11,020.8 acres of Seneca State Forest, Pocahontas County, West Virginia. Both areas were mapped during late spring and summer months.

Variations in such items as salaries and distances from field quarters to work areas do not permit of detailed cost analysis and comparisons. However, the project Leader's salary does afford a means of comparing a stable cost item. At $300.00 per month, Leader's salary, approximately $.33 per acre was spent in mapping Short Mountain Game Refuge as contrasted with $.15 per acre for Seneca State Forest.

If accuracy be desired in transferring feature delineation to the completed map, radial line plotting should be used. Since some shrinkage occurs in the

blueline process, it is recommended that a graphic scale be used. Errors in area measurement can be distributed between types crossed by the property lines.

When the difference in scale between the upper and lower limits of elevation is as low as two chains, it is seldom necessary to adjust the photo scale from sea level to ground elevation for each plot taken. The measured distances are sufficiently close and the mapper also has the photographs should he desire to check his location. In homogeneous types pinpoint location of plots is not requisite.

SUMMARY

1. Repetitive patterns of vegetation, adaptable to efficient and informative type mapping of forest cover in mountainous terrain, can be established through knowledge of ecological principles in conjunction with the use of aerial photographs.
2. Vertical aerial photographs taken at a scale of 1:15,840 or 1:20,000 are adequate for such typing.
3. Using stereoscopic vision the desired features are delineated on the photographs following which two base maps are prepared, one for purposes of control and the other for cover map construction.
4. Watersheds, soil types, sample plots, and check lines are entered on the control map. Cover types are entered on the other map.
5. Type mapping and sampling are done in parties of two. First, roads and trails are travelled and edge vegetation mapped. Second, the vegetation is sampled, and the cover types delineated and designated by code number on the photographs. Third, check lines, for mapping areas not covered during sampling, are run at the mapper's convenience. Each day the types are taken from the photographs and placed on the cover map in the office.
6. Rock structure, slope, soil type, soil depth, and soil moisture are influential in the development of striking differences in vegetation which, as disclosed by mapping, occur in repetitive patterns. Once the pattern becomes apparent, the mapper can then delineate that portion of the pattern which has not been mapped. Considerable time is saved.
7. Upon completion of cover mapping, the sample plot data are utilized to derive cover type formulas which are entered on the final map. Inset maps showing soil types, drainage basins, and topography, together with climatological data and soil descriptions in the legend, give a more complete concept of the ecological factors operative in the development and structure of the vegetation.
8. Based upon a cost item, unaffected by variations in regional wage scales, salaries, and travel time, 8,878 acres were mapped by the line-plot method without aerial photographs at a cost of $.33 per acre. Using aerial photographs, random sampling, and pattern mapping 11,020.8 acres were mapped at a cost of $.15 per acre.

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A TWO-SUMMER STUDY OF THE EFFECTS ON BIRD POPULATIONS OF CHLORDANE BAIT AND ALDRIN SPRAY AS USED FOR GRASSHOPPER CONTROL[1]

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INTRODUCTION

During the past three years, the insecticides chlordane, toxaphene, and aldrin have been extensively used for the control of grasshoppers in certain western states (Annual Control Reports of the Division of Grasshopper Control, 1949, 1950, and 1951). This widespread useage has aroused considerable concern as to the effects on wildlife populations.

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Post (1951) determined through laboratory experiments the minimum lethal dose of chlordane and toxaphene for three species of game birds. He also made extensive field observations in Wyoming following the use of these insecticides for grasshopper control. Jackson (unpublished thesis) fed chlordane and toxaphene treated food to penned pheasants. Linduska and Springer (1950) determined by feeding tests the comparative toxicity of chlordane and toxaphene for bobwhite quail. The present paper summarizes the results of a two-summer study in Montana of the effects of chlordane and

aldrin on bird populations, under field conditions, following their application for grasshopper control.

For help during the study, the writer extends his sincere appreciation to the following: Dr. Don C. Quimby, Montana State College, who directed the study and assisted with the manuscript; the Montana Fish and Game Department for financial support and assistance and advice of their staff, especially W. K. Thompson, W. H. Bergeson, and F. L. Hartkorn; the U. S. Bureau of Entomology for treating the experimental plot with chlordane bait and use of a vehicle; and the Montana State Entomologists Office for treating the experimental plot with aldrin and for financial assistance.

METHODS

An effort to determine the effects was made by comparing the population index, number of resident pairs, and development of nestling birds on a treated plot, before and after application of the insecticides, with similar data from an untreated plot. Further data of a more general nature were gathered by observations on larger treated areas.

Two square 40-acre study plots, $2\frac{1}{3}$ miles apart, were selected in Powder River County, Montana, 17 miles southeast of Ashland. Otter Creek Valley, where the plots were located, is bordered on both sides by Custer National Forest. Plot I was used as a control plot, Plot II as a treated plot.

Each plot was cover-mapped. With the exception of 3.5 acres of cultivated land on Plot II, the study plots were on winter and spring cattle ranges. For the most part, the areas are grassland. The most common grass is bluestem, *Agropyron smithii*, although Japanese chess, *Bromus japonicus*, downy chess, *Bromus tectorum*, and others are locally dominant. Big sage, *Artemesia tridentata*, is found in varying degrees of abundance throughout the areas. Otter Creek, a small, sluggish stream, meanders through both plots. Along the course of the stream are scattered clumps of boxelder, *Acer negundo*, and less frequently small groups of cottonwood, *Populus sargentii*. The dominant shrubs found along the stream are snowberry, *Symphoricarpos* sp., and rose, *Rosa* sp.

Following the method of George and Stickel (1949), the central 25.6 acres of each plot was staked into 16 equal squares, forming transect lines through the area every 264 feet.

One square mile, including Plot II approximately in the center, was treated by airplane with chlordane bait at the usual rate of ten pounds per acre on June 22, 1950 under the direction of personnel from the U. S. Bureau of Entomology and Plant Quarantine. The bait was the same as that used in routine grasshopper control work, consisting of one-half pound of chlordane in one-half gallon of kerosene mixed with 100 pounds of dry bran. On June 20, 1951, 400 acres, surrounding and including Plot II, were treated by airplane with aldrin spray at the usual rate of two ounces per gallon of fuel oil to the acre under the direction of personnel from the Montana State Entomologists Office.

Both plots were censused daily before and after insecticidal treatment of Plot II, 13 and 12 days for Plots I and II respectively before chlordane baiting

in 1950, and 17 for each following baiting. In 1951, when Plot II was sprayed with aldrin, the number of censuses was the same except Plot II received the extra pre-treatment census. The censuses began at 5:30 and 9:30 A. M. Each required about 1½ hours. The early census was alternated between the plots. The transect lines were walked slowly, and all birds observed within approximately 132 feet on either side were recorded by species number on an outline map. A new map was used each day. Birds displaying territorial traits were designated by symbols. Species numbers, recorded on cross-transects, were encircled to indicate the possibility of duplication. Following the field work, the daily census sheets were grouped into pre- and post-treatment census periods for each plot (only Plot II treated). Then, an index of the daily population was derived by determining the average number of birds seen per day during the census period. Censuses conducted during adverse conditions (weather or agricultural activity) were considered inadequate for computing daily population indices. The number of resident pairs for each plot during a census period was determined by examination of the daily census sheets. Those birds showing territorial behavior, such as singing or defense activity, in the same general area five times or more (5 to 13 pre-treatment, 5 to 17 post-treatment) during the census period were considered as resident pairs. Exceptions were made in cases where nests were located. Familiarity with the census plots greatly facilitated these determinations. Williams (1936) used a similar method.

Both plots were systematically searched for nests. Those located were plotted by number on a map. Nests adjacent to Plot II, but well within the area to be treated, were also included. The progress of nesting activities for each nest was recorded from observations taken at three to five day intervals during the period prior to treatment of Plot II. Following application of the insecticide, the nests containing nestlings were observed daily until each nest had terminated. Young were considered successfully reared when they reached the fledgling stage. Nestlings not found on the treated area until after insecticidal treatment were compared with young of known age to determine their stage of development at the time Plot II was treated.

While censusing Plot II, following its treatment with chlordane or aldrin, a constant vigil was kept for sick and dead birds. An additional 24 and 38.5 man hours were spent searching the entire treated area following chlordane baiting and aldrin spraying respectively.

To supplement the data from the study plots, observations were made on a 55 thousand acre area of rangeland in Rosebud and Powder River Counties which was baited with chlordane, and on 95 acres of crop and grassland in Sheridan County which were sprayed with aldrin. Both applications were made at the same rates as applied to Plot II. A total of 85.5 man hours was spent driving and walking 123 and 36 miles respectively, over the chlordane baited area from July 10 to 24, 1950. Twenty-eight man hours were spent walking over the aldrin sprayed area from July 27 to August 5, 1950. Beginning three days after spraying, a route of 2½ miles was covered daily,

during which the principal species observed were recorded. Particular emphasis was placed on attempting to locate dead and/or sick birds.

RESULTS

Chlordane

Grasshopper populations on the experimentally baited plot (Plot II) showed a decrease following baiting from 30 to 10 per square yard on the higher areas, and from 60 to 35 on the lower more heavily vegetated areas (population estimates made by C. R. Pratt of the U. S. Bureau of Entomology and Plant Quarantine).

The average number of birds observed per day on Plots I (control plot) and II (baited plot) during the pre- and post-baiting census periods is shown by species in Table 1. The average number on the baited plot was 68.16 during the pre-baiting, and 62.41 during the post-baiting census period, a decrease of 5.75 birds or 8.4 percent. Totals from the control plot over the same periods were 77.84 and 80.64, an increase of 2.8 birds or 3.1 percent. These data suggest that the chlordane bait may have affected the population on the baited plot because its average daily population index decreased following baiting, whereas that of the control plot increased slightly. The inclusion of certain species seen only occasionally on the plots may distort the true picture since there is the possibility of their being there as "strays" during the census periods. Considering only the most abundant bird, the western meadowlark, the trend for both plots is somewhat the same, showing an increase for both following baiting of Plot II (Table 1).

Table 2 shows the number of resident pairs of birds on Plots I and II, before and after chlordane baiting of Plot II. The totals of resident pairs on the baited plot during the pre- and post-baiting census periods were 37 and 44 pairs respectively, showing an increase following baiting of 7 pairs or 18.9 percent. These totals for the control plot during the same census periods were 40 and 45 pairs, showing an increase of 5 pairs or 12.5 percent. The figures for the two plots show the same general trend suggesting that chlordane bait had no appreciable effect on the number of resident pairs on Plot II. Considering only the western meadowlark, the most common resident, there is evidence of some effect. The baited plot showed no increase in resident pairs whereas the resident pairs on the control plot increased 21.4 percent. For a discussion of the possible cause of this effect, see effects of aldrin on resident pairs in a later section.

Data from Plots I and II summarizing the fate of nestling birds, which hatched before or soon after baiting of Plot II, are found in Table 3. The majority of the nests located on the control plot were those of the western meadowlark which appeared to be approximately ten days more advanced than those available for comparison on the baited plot. The numbers appearing in the "Number of Days Observed" column for the control plot in Table 3 are counted from a date ten days earlier than those on the baited plot, but are included to show the amount of natural mortality present during this stage of development. There was a 6.2 percent mortality of nestlings for the baited plot and 12.1 percent for the control plot. No particular significance can be attached to their dif-

TABLE 1.—AVERAGE NUMBER OF BIRDS * OBSERVED/DAY ON PLOTS I AND II, BEFORE AND AFTER CHLORDANE BAITING, 1950. ONLY PLOT II BAITED

	PLOT I Control Plot			PLOT II Baited Plot		
	June 9–21	June 23–July 9	% Change	June 10–21 (Pre-baiting)	June 23 to July 9 (Post-baiting)	% Change
Sparrow Hawk	.38	.41	+ 7.9			
Sharptail Grouse	.69	.24	− 65.2	.08		−100.0
European Partridge	.15		−100.0			
Ring-necked Pheasant	.15		−100.0	1.50	.59	− 60.7
Killdeer	.15		−100.0	1.25	.29	− 76.8
W. Mourning Dove	.46		−100.0	.35	.41	+ 17.1
Black-billed Cuckoo		.41			.53	
Red-shafted Flicker	.62	1.12	+ 80.6	1.50	2.24	+ 49.3
Eastern Kingbird	4.46	5.06	+ 13.4	2.83	2.88	+ 1.8
Arkansas Kingbird	1.00	2.24	+124.0	2.75	.65	− 76.4
Say's Phoebe	.15		−100.0			
W. Wood Pewee	.31		−100.0			
Magpie				.17		−100.0
W. House Wren	2.54	3.00	+ 18.1	1.17	2.53	+116.2
Brown Thrasher	.62	1.06	+ 71.0	.08	.06	− 25.0
Robin				1.00	.24	− 76.0
Yellow Warbler	4.77	3.64	− 23.7	5.67	4.53	− 20.1
Yellowthroat	3.38	2.47	− 26.9	2.58	4.06	+ 57.4
Long-tailed Chat	1.23	.29	− 76.4	2.67	.88	− 67.0
W. Meadowlark	28.15	29.00	+ 3.0	16.00	17.47	+ 9.1
Redwing	10.62	14.29	+ 34.6	8.67	11.12	+ 28.2
Bullock's Oriole	6.46	7.41	+ 14.7	4.83	3.29	− 18.8
Bronzed Grackle	5.38	5.94	+ 10.4	2.92	.47	− 83.9
Cowbird				.42		−100.0
Western Tanager	.08	.06	− 25.0			
Black-headed Grosbeak	1.54	1.35	− 12.3	.50	.70	+ 40.0
Lazuli Bunting	.69	.47	− 31.8	2.25	1.88	− 16.4
Goldfinch				.08		−100.0
Lark Bunting	.46	.18	− 60.9	3.25	1.12	− 65.5
Vesper Sparrow				.75		−100.0
W. Lark Sparrow	2.69	2.00	− 25.6	4.92	6.47	+ 51.8
W. Chipping Sparrow	.69		−100.0			
TOTAL	77.84	80.64	+ 3.1	68.16	62.41	− 8.4

* Bird names follow nomenclature of American Ornithologists' Union Checklist.

ference, suggesting that the chlordane bait had no effect on the development of nestlings. These data seem especially significant because some of the nesting birds (western meadowlark, redwing, lark sparrow) on the baited area were seen feeding grasshoppers to their young. It seems probable that many of these grasshoppers were those that had consumed chlordane bait. Jackson (unpublished thesis) fed penned pheasants food which had been treated with the maximum calculated amount of chlordane which would normally be encountered under field conditions. He found neither mortality nor loss in body weight in his experimental birds over a period of four weeks.

No dead or sick birds were observed on either the experimental baited plot or the larger baited area in Rosebud and Powder River Counties. It is probable that affected birds could have been overlooked. However, it seems logical

TABLE 2.—RESIDENT PAIRS OF BIRDS ON PLOTS I AND II, BEFORE AND AFTER CHLORDANE BAITING, 1950. ONLY PLOT II BAITED

	PLOT I Control Plot			PLOT II Baited Plot		
	June 9–21	June 23–July 9	% Change	June 10–21 (Pre-baiting)	June 23 to July 9 (Post-baiting)	% Change
Sparrow Hawk	1	1	0.0			
Killdeer				1	1	0.0
Black-billed Cuckoo					2	
Red-shafted Flicker				1	1	0.0
Eastern Kingbird	1	3	+200.0	1	1	0.0
Arkansas Kingbird	1	1	0.0	1	1	0.0
House Wren	2	2	0.0	1	2	+100.0
Brown Thrasher	1	1	0.0			
Yellow Warbler	2	4	+100.0	2	4	+100.0
Yellowthroat	2	2	0.0	2	3	+ 50.0
Longtailed Chat				1	1	0.0
Meadowlark	14	17	+ 21.4	13	13	0.0
Redwing	6	5	− 16.6	3	4	+ 33.3
Bullock's Oriole	2	3	+ 50.0	2	2	0.0
Bronzed Grackle	3	2	− 33.3	1		−100.0
Black-headed Grosbeak	2	2	0.0	1	2	+100.0
Lazuli Bunting	1	1	0 0	1	2	+100.0
Lark Bunting				1	1	0.0
Vesper Sparrow				1		−100.0
Lark Sparrow	1	1	0.0	4	4	0.0
Chipping Sparrow	1		−100.0			
TOTAL	40	45	+ 12.5	37	44	+ 18.9

to assume that some evidence of deleterious effects would have been noticed if there had been a high degree of affliction because many normally appearing birds were seen. Birds present on the experimental plot are listed in Table 1. The western meadowlark and sharp-tailed grouse were the birds most commonly seen on the larger baited area, young of both being observed closely. One flock of adult sharptailed grouse, ranging from seven to ten birds was observed regularly. Young of upland plovers, vesper sparrows, redheaded and Lewis's woodpeckers and nighthawks were observed close at hand. These observations do not conform with Post's (1951) findings. He reported finding many dead and affected birds on chlordane baited areas. The two sets of data are not entirely comparable since he points out that from 5 to 35 pounds of chlordane bait per acre were applied during the control program. The extent of application on the exact areas where the affected birds were located was evidently not known.

Aldrin

Before the application of aldrin spray to Plot II, the grasshopper population ranged from 5 to 65 per square yard. Following the spraying, a steady decline was noted for four days, until a population of less than one per square yard was present. These figures were obtained through quantitative measurements of the population by N. L. Anderson of the Montana State Entomologists Office.

TABLE 3.—FATE OF NESTLING BIRDS HATCHED BEFORE OR SOON AFTER CHLORDANE BAITING ON PLOT II, 1950. EARLIER FIGURES FOR PLOT I (CHECK PLOT) INCLUDED FOR COMPARISON.*

Species	No. Young Hatched	No. Days Observed In Nest Following Baiting	Number Successfully Reared	% Mortality	Remarks
PLOT II—BAITED PLOT					
Red-shafted Flicker	?	7 days	5	...	
W. Meadowlark	5	13 days	5	0	
Redwing	3	11 days	2	33.3	1 found dead below nest.
Lark Bunting	3	3 days	3	0	
Lark Sparrow	5	5 days	5	0	
TOTAL	16		15	6.2	
PLOT I—CONTROL PLOT					
W. Meadowlark	5	8 days	5	0	
W. Meadowlark	5	12 days	4	20.0	1 unaccounted for.
W. Meadowlark	5	12 days	5	0	
W. Meadowlark	4	8 days	4	0	
W. Meadowlark	4	12 days	4	0	
Redwing	1	1 day	0	100.0	1 unaccounted for.
Bullocks Oriole	4	5 days	4	0	
Bronzed Grackle	5	11 days	3	40.0	1 found dead in nest. 1 unaccounted for.
TOTAL	33		29	12.1	

* Nests on Plot I were approximately ten days earlier than on Plot II.

The average number of birds observed per day on Plots I (control plot) and II (sprayed plot) during the pre- and post-spraying census periods is given by species in Table 4. Four censuses were considered invalid for use in computing daily averages on the two plots due to adverse censusing conditions. The sprayed area had a daily average of 92.38 for the pre-spraying, and 83.64 for the post-spraying census period, a decrease of 8.74 birds or 9.5 percent. Daily averages for the control plot during the same periods were 86.0 and 80.56 respectively, a decrease of 5.44 birds or 6.3 percent. The western meadowlark shows similar trends on both areas following the spraying of Plot II (Table 4). These data do not indicate any great differences in the changes in the population indices of the two plots following spraying of Plot II.

The resident pairs of birds present on Plots I and II, during the census periods before and after the spraying of Plot II are summarized in Table 5. A total of 43 pairs was present on the sprayed plot during the pre-spraying and 39 during the post-spraying census period, showing a decrease of 4 pairs or 9.3 percent. Totals on the control plot for the same periods were 38 and 40 pairs respectively, an increase of 2 pairs or 5.3 percent. The pair of killdeers and both pairs of magpies present on Plot II during the pre-spraying and not during the post-spraying census period were known to have successfully reared young and moved off the plot during the pre-spraying census period. On Plot I, the pair of lark sparrows abandoned the nest and moved off the plot before the post-spraying census period. Omitting these pairs from the plots, the percentage change for Plots I and II were +8.1 and −2.5 percent respectively. Based on the numbers of each species resident on the plots, the most striking difference in the change of resident pairs between the two plots following the spraying of Plot

TABLE 4.—AVERAGE NUMBER OF BIRDS OBSERVED/DAY ON PLOTS I AND II, BEFORE AND AFTER ALDRIN SPRAYING, 1951. ONLY PLOT II SPRAYED.

	PLOT I Control Plot			PLOT II Sprayed Plot		
	June 8–19	June 21–July 7	% Change	June 7–19 (Pre-spraying)	June 21–July 7 (Post-spraying)	% Change
Mallard				.77	.57	− 26.0
Sparrow Hawk	1.00	2.25	+125.0			
Sharptail Grouse		1.62				
Sage Hen		.50				
Ring-necked Pheasant	.25	.06	− 76.0	.38	1.43	+276.3
Killdeer		.06		.85		−100.0
W. Mourning Dove	.25	.19	− 24.0	1.08	1.07	− 0.9
Black-billed Cuckoo	.58	.69	+ 19.0	.23	.93	+304.3
Red-shafted Flicker	1.00	1.12	+ 12.0	1.62	1.14	− 29.6
Hairy Woodpecker				.08		−100.0
Eastern Kingbird	3.08	2.62	− 14.9	6.92	7.28	+ 5.2
Arkansas Kingbird	2.83	1.94	− 31.4	.92	.14	− 84.8
Magpie	.17		−100.0	6.00	3.00	− 50.0
W. House Wren	1.42	1.25	− 12.0	1.38	2.21	+ 60.1
Brown Thrasher	.17	.06	− 64.7	.08	1.00	+1150.0
Robin	.25	.12	− 52.0	1.08	.14	− 77.8
Cedar Waxwing				.15		−100.0
Yellow Warbler	3.42	1.25	− 34.2	3.77	3.28	− 13.0
Yellowthroat	1.33	.81	− 39.1	3.62	2.64	− 27.1
W. Meadowlark	36.17	40.31	+ 11.4	15.31	18.50	+ 20.8
Redwing	16.92	14.62	− 13.6	20.85	20.14	− 3.4
Bullock's Oriole	5.58	5.19	− 7.0	6.08	3.78	− 37.8
Bronzed Grackle	6.83	4.81	− 29.6	9.23	5.57	− 39.6
Cowbird				.08		−100.0
Black-headed Grosbeak	.25	.38	+ 52.0	.23	.36	+ 56.5
Lazuli Bunting	.17	.19	+ 11.7	1.08	2.00	+ 85.2
Goldfinch	.08		−100.0	.31	.64	+106.4
Arctic Towhee	.08	.06	− 25.0	1.15	.86	− 25.2
Lark Bunting	2.58	.06	− 97.7	1.23	1.00	− 18.7
W. Lark Sparrow	1.58	.38	− 75.9	7.92	5.93	− 25.1
TOTAL	86.00	80.56	− 6.3	92.38	83.64	− 9.5

II concerns the western meadowlark (Table 5). Field observations gave some clues as to the probable cause. Most of the young of the first broods of this species were leaving the nests at the time of spraying (observations indicated that this species raised two broods). "Second nestings" were begun several days after the grasshopper kill was complete. It is possible that the sprayed area was not as attractive for nesting due to the scarcity of grasshoppers as compared to nearby areas. It is well known that meadowlarks feed heavily on grasshoppers at this season. These data suggest that the resident bird population on the treated area was affected by the aldrin.

The fate of nestling birds on Plots I and II, which hatched before or soon after the spraying of Plot II, is summarized in Table 6. A greater mortality of nestling birds occurred on the sprayed plot (27.5%) than on the control plot (13.7%). Nestling redwings supplied the greatest amount of data because their hatching date coincided closely with the spraying date of Plot II. There was a

TABLE 5.—RESIDENT PAIRS OF BIRDS ON PLOTS I AND II, BEFORE AND AFTER ALDRIN SPRAYING, 1951. ONLY PLOT II SPRAYED.

	PLOT I Control Plot			PLOT II Sprayed Plot		
	June 8–19	June 21–July 7	% Change	June 7–19 (Pre-spraying)	June 21–July 7 (Post-spraying)	% Change
Sparrow Hawk	1	1	0.0			
Killdeer				1		−100.0
Black-billed Cuckoo		1			1	
Red-shafted Flicker	1	1	0.0	1	1	0.0
Eastern Kingbird	1	1	0.0	3	3	0.0
Arkansas Kingbird	1	1	0.0			
Magpie				2		−100.0
House Wren	1	1	0.0	2	2	0.0
Brown Thrasher					1	
Robin				1		−100.0
Yellow Warbler	3	2	− 33.3	2	1	− 50.0
Yellowthroat	2	2	0.0	2	3	+ 50.0
Meadowlark	18	21	+ 16.7	14	13	− 7.1
Redwing	4	5	+ 25.0	6	6	0.0
Bullock's Oriole	3	3	0.0	2	2	0.0
Bronzed Grackle	2	1	− 50.0	2	1	− 50.0
Lazuli Bunting				1	1	0.0
Arctic Towhee				1	1	0.0
Lark Sparrow	1		−100.0	3	3	0.0
TOTAL	38	40	+ 5.3	43	39	− 9.3

TABLE 6.—FATE OF NESTLING BIRDS HATCHED BEFORE OR SOON AFTER ALDRIN SPRAYING ON PLOT II, 1951. SIMILAR FIGURES FOR PLOT I (CHECK PLOT) INCLUDED FOR COMPARISON.

PLOT II—SPRAYED PLOT

Species	Number Young Hatched	No. Days Observed In Nest Following Baiting	Number Successfully Reared	% Mortality	Remarks
Yellow Warbler	4	6 days	4	0	
Yellow Warbler	4	4 days	4	0	
W. Meadowlark	7	7 days	6	14.3	1 unaccounted for.
Redwing	4	2 days	2	50.0	1 found dead below nest. 1 unaccounted for.
Redwing	5	8 days	0	100.0	2 found dead in nest. 3 unaccounted for.
Redwing	3	6 days	0	100.0	2 found dead in nest. 1 unaccounted for.
Redwing	4	5 days	4	0	
Redwing	4	7 days	4	0	
Bullock's Oriole	?	11 days	4	...	
Lark Sparrow	5	4 days	5	0	
TOTAL	40		29	27.5	

PLOT I—CONTROL PLOT

Yellow Warbler	5	4 days	4	20.0	1 unaccounted for.
W. Meadowlark	6	7 days	5	16.6	1 unaccounted for.
Redwing	5	6 days	5	0	
Redwing	5	10 days	4	20.0	1 found dead below nest.
Redwing	3	6 days	3	0	
Bullock's Oriole	5	10 days	4	20.0	1 unaccounted for.
TOTAL	29		25	13.7	

higher degree of mortality in nestlings of this species than in those of the other species. Considering the redwing alone, a 50 percent loss of nestlings was recorded from the sprayed plot while only a 7.7 percent loss was recorded for the control plot. The fate of two nests on the sprayed area was especially striking. All of the young (3 and 5) were found dead in their nests or missing within eight days after spraying (Table 6). The young from the two nests had hatched one and two days before the spraying. These nests were located 200 feet apart, near a large flat which before the spraying had had the heaviest grasshopper populations. Adult redwings from the area where the nests were located had been observed feeding regularly on this flat before and for a short time after the spraying. The amount of feeding on this flat was observed to be greatly reduced by eight days after spraying. The young found dead in these nests were examined for food content. The digestive tract of each was empty with the exception of one which contained parts of a beetle in the gizzard. This might lead one to suspect that the young died of starvation. (Unfortunately, the young were not analyzed for the presence of aldrin.) The cause(s) of these complete nesting failures is, of course, unknown, but the fact that the development of these nests was so completely different from others observed during the two summers suggests some relationship to the spraying operation and its subsequent effects. These nestling data point to the conclusion that the aldrin spray adversely affected the development of nestlings.

No dead or sick adult birds were observed on either the experimentally sprayed plot or on the sprayed area in Sheridan County. In addition to the birds listed in Table 4 for study Plot II, sage hens were observed on the experimentally sprayed area. A few small flocks of two or three were seen and the activities of a single flock of nine adults were closely watched for approximately one-half hour on three consecutive days beginning with the fifth day after spraying. The pheasants observed on the experimentally sprayed area during the post-spraying census period consisted of single males and three individual hens with broods which were seen on different occasions. During the time spent on the sprayed area in Sheridan County, an average of 35 birds was observed daily. The species present, listed in order of their numerical importance, were the savannah sparrow, chestnut-collared longspur, sharp-tailed grouse, redwing, western meadowlark, vesper sparrow, and horned lark. The sharp-tailed grouse observed composed a flock ranging in numbers from 8 to 12 and were seen regularly in the same area.

DISCUSSION AND CONCLUSIONS

No positive evidence of bird mortality which could be attributed directly to the toxicity of either chlordane or aldrin was obtained. It is true that some mortality in redwing nestlings was evidently associated with the aldrin spray, but there was evidence suggesting a lack of food as being a contributing factor. Even assuming that these nestlings were killed directly by the effects of the insecticide, the fact still remains that when all available data are considered, the effects due to toxicity of the insecticides were of little importance.

On the other hand, there was evidence

to indicate that the bird populations on the treated plot were adversely affected by the reduction of grasshopper numbers brought about by the insecticides. The magnitude of this effect seemed to be in proportion to the efficiency of the insecticide in reducing the grasshopper population. Aldrin spray effected a near 100% reduction in grasshopper numbers, whereas chlordane bait reduced the population by only about 50%. The number of resident pairs and the development of nestlings seem to be more valuable criteria for evaluating the effects of the insecticides on the bird populations than daily population indices, because of the somewhat unstable character of the latter. Following the application of aldrin to Plot II, there was apparently a reduction in the total number of resident pairs. This reduction was more marked for the western meadowlark, the most common resident, making it more amenable to quantitative measurements. When chlordane bait was used, there was apparently no reduction in total residents, but the western meadowlarks exhibited the same trend as when aldrin spray was used. As was previously stated, there was evidence of adverse effects of the aldrin spray on the development of certain nestlings whereas no such data were available following chlordane baiting. The data lead to the conclusion that a reduction of the grasshopper population by as much as 50 percent (chlordane) was sufficient to make the area less desirable for resident pairs but not to affect the development of nestlings. A near 100 percent reduction of the grasshopper population (aldrin) made the area even less desirable for resident pairs and also appeared to affect adversely development of certain nestlings.

SUMMARY

1. A study of the effects of chlordane baiting and aldrin spraying for grasshopper control on bird populations was conducted during the summers of 1950 and 1951.
2. Two square, 40-acre study plots (treated and control) were selected on rangeland near Custer National Forest in southeastern Montana.
3. An effort to determine the effects was made by comparing population index, number of resident pairs, and development of nestling birds on the treated plot, before and after application of the insecticide, with similar data from the control plot. Data of a more general nature were gathered by observations on larger treated areas.
4. In 1950, chlordane bait was applied at the usual rate of ten pounds per acre to one square mile surrounding and including one study plot.
   a. The bird population index on the baited plot before and after baiting was 68.16 and 62.41 respectively, a decrease of 8.4 percent. Figures from the control plot over the same periods were 77.84 and 80.64, an increase of 3.1 percent.
   b. Resident pairs of birds on the baited plot, before and after baiting, numbered 37 and 44 respectively, an increase of 18.9 percent. Totals for the control plot, over the same periods, were 40 and 45 pairs, an increase of 12.5 percent. The most abundant bird on both plots, the western meadowlark,

showed an increase on the control and remained somewhat stable on the treated plot following baiting.

c. Development of nestling birds on the baited plot following baiting appeared similar to that of nestling birds of equal age on the control plot.

d. Considerable searching on the baited plot and on additional baited areas revealed no sick or dead birds.

5. In 1951, aldrin spray was applied at the usual rate of two ounces of aldrin in one gallon of fuel oil per acre to 400 acres, surrounding and including one study plot.

a. The sprayed plot had a bird population index of 92.38 before and 83.64 after spraying, a decrease of 9.5 percent. Figures for the control plot for the same periods were 86.00 and 80.56, a decrease of 6.3 percent.

b. Resident pairs on the sprayed plot totaled 43 pairs before spraying and 39 after, a decrease of 9.3 percent. Totals for the control plot over the same periods were 38 and 40, an increase of 5.3 percent. The western meadowlark exhibited an increase on the control and a decrease on the sprayed plot following spraying.

c. Nestling redwings exhibited a higher mortality rate (50%) on the sprayed than on the control plot (7.7%). Mortality rates of nestlings of other species on the sprayed plot were similar to those on the control plot.

d. No sick or dead adult birds were observed on the experimentally sprayed plot or on other sprayed areas.

6. No positive evidence of bird mortality due directly to the toxicity of the insecticides was obtained. Some adverse effects on the bird populations were noted. These effects were apparently associated with reduction in grasshopper numbers, appearing to be in direct proportion to the extent of the grasshopper kill.

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A METHOD OF EVALUATING AN ANNUAL MAST INDEX*

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Introduction

The Conservation Commission of West Virginia has been undertaking extensive surveys of the annual mast crop since 1943. Conservation officers, foresters and game technicians were asked to estimate mast conditions by species. Recently the information has been systematically compiled so that comparisons could be made with climatological data and the annual wild turkey harvest, (information on other wildlife species being unavailable).

The methods used in dividing the state into regions, and obtaining a group mast index by regions and on a state-wide basis, are incorporated in this paper for the benefit of those interested in inexpensive broad surveys of this type. In mountainous states such as West Virginia the distribution of vegetation, the annual mast crop, and the annual harvest of game are affected directly or indirectly by a number of variable habitat factors. For this reason the state was divided into six ecological regions.

The Basis for Regional Divisions

The distribution and structure of plant communities are closely associated with factors of habitat which may be classified as follows: (1) those directly influencing plant functions; (2) those exerting an indirect effect upon plant activity; and (3) those remotely affecting plants through indirect factors. Water content, humidity, light, temperature, solutes, soil and air are direct factors. Included among the indirect factors are precipitation, soil composition, wind, and pressure. Classified as remote factors are altitude, slope, exposure, and surface (Weaver and Clements, 1938).

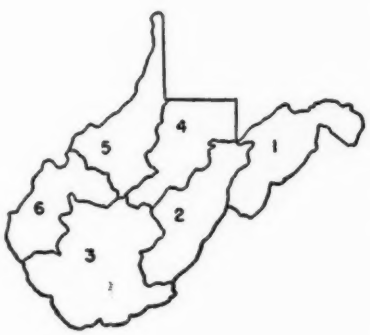
Temperature, precipitation, growing season, physiographic subdivisions, soils, and predominant forest types (Table 1) were selected as the basis for dividing the state into six ecological regions exhibiting more or less uniform zones of habitat factors and vegetation (Figure 1). Overlapping, though present, was eliminated to considerable degree by careful selection of regional boundaries adjusted to county outlines. County outlines were also used because data pertaining to the mast crop and game harvest is submitted on this basis. While closely similar in zonation of habitat factors and distribution of forest types, western West Virginia was divided into two regions for convenient handling of mast data.

* A contribution from Pittman-Robertson Restoration Projects 26-R and 21-R, Conservation Commission of West Virginia, Division of Game Management. The writers are indebted to Dr. Ward M. Sharp, Penn. Cooperative Wildlife Research Unit, Dr. Earl L. Core, Head Dept. of Biology, West Virginia University and Dr. Samuel A. Graham, Professor of Economic Zoology, University of Michigan for critical comment on the manuscript.

TABLE 1.—REGIONAL DIVISIONS BY ECOLOGICAL FACTORS

Ecological Factors	Regions					
	I	II	III	IV	V	VI
Physiographic Sub-divisions	Allegheny Ridges and Valleys	Allegheny Plateau	Cumberland Mountains	Monongahela-Upper Ohio	Ohio-West Virginia Hills	
Soils	Lithosols and Shallow soils	1/4th. Gray-Brown Podzols; 3/4th. Podzols	1/3rd. Lithosols, Shallow soils, and Podzols; 2/3 rd. Gray-Brown Podzols	Podzols	Lithosols and Shallow soils	
Growing Season (days)	153	143	173	155	165	171
Average Annual Temperature (F)	52°-54°	48°-52°	52°-56°	48°-54°	52°-56°	
Average Annual Precipitation (inches)	30-40	40-60	Southeastern section 40-45; remainder 40-60	40-50	40-50	
Predominant Forest Types	red oak; hard pine-oak	northern hardwoods; red oak	cove hardwoods; red oak	cove hardwoods, red oak	red oak	cove hardwoods; red oak

Figure 1. Ecological Regions of West Virginia



THE MAST INDEX

Method:

In order to derive the mast index each cooperator was asked to describe the available fruit by using the terms, Abundant (above normal crop), Common (normal crop), or Scarce (below normal crop). A total of 209 reports were received in 1950. The number of reports in former years ranged from 50 to 100. An index to the mast condition was derived by calculating the per cent of the total men reporting each of the above categories. Each "Abundant" per cent was then given a value of 100, and each "Common" per cent was given a value of 50. The sum of the two figures gave the index for the species. "Scarce" was given a value of zero.

In order to obtain an overall mast index the species listed were divided into two groups based on their crown position in the forest community:

GROUP A

Beech (*Fagus grandifolia*)
Black walnut (*Juglans nigra*)
Butternut (*Juglans cinerea*)
Hickories (*Carya spp.*)
White Oak Group (*Quercus spp.*)
Black Oak Group (*Quercus spp.*)

GROUP B

Scrub oak (*Quercus sp.*)
Hazelnut (*Corylus americana*)
Hawthorne (*Crataegus spp.*)
Crabapple (*Malus sp.*)
Dogwood (*Cornus spp.*)
Grapes (*Vitis spp.*)
Blackberries (*Rubus spp.*)

The group mast index was obtained by applying the following formula:

$$\frac{(An)+(Bn)+(Cn)+etc.}{n} = \text{Group Index}$$

A, B, C, etc., indicate individual species indices in the group.
n = number of observers reporting on the individual species.

For more intensive use in wildlife work the index could be further weighted on the basis of wildlife utilization and by the relative abundance of the individual fruiting species. However, additional intensive work is needed before this can be done with any degree of accuracy.

Results—Mast Index

Although the index ratings for Group B are usually higher than the rating for Group A, the yearly trend is similar.

The years 1945 and 1947 were considered poor mast years because the species in Group A were below the index rating of 50 which is considered a fair mast crop. The year 1944 fell on the borderline with an even rating of 50. The general opinion was that 1947 was a very poor mast year even in comparison to 1945 although the latter index was several points lower. It is believed, however, that the good mast crop during 1946 influenced the general opinion in this respect. The index method, therefore, is an arbitrary aid in making annual comparisons that are not influenced by general opinion.

An interpretation of Park's article (1942) suggests that 1935 was a good mast year with all 27 species observed bearing fruit. In 1936 and 1937, 33 per cent failed to bear and 29 per cent failed to bear in 1938.

Index ratings for individual species and by regions are available, but are not given in this paper. An unusual decrease in the Group B mast index occurred in 1950. This was attributed to the comparative failure of grape, blackberry and hazelnut. It is believed that the precipitation affected the blackberry and wild grape crop. The precipitation during May, June and July 1950 was .79, 1.53, and 1.12 inches above normal, respectively, which was higher than any other year since 1943.

Climatological Data and the Group Mast Index—

In order to determine correlations between the mast index and climatic factors several comparisons were made with the mast index and precipitation and frosts. Most of the species flower either in April, May or June, and it is at this period that the plant species are most vulnerable to climatic factors. Many of the plant species are wind pollinated and therefore a prolonged rainy season could reduce the flight of pollen. This factor is generally believed to reduce the chances of pollination although there is no published work to prove it. Insect pollination may be affected by adverse weather conditions. After fertilization favorable weather is necessary for the ripening of the fruit. Frosts can and often do kill the flower before fertilization can take place. It is clearly seen

that many factors are involved in the production of a seed crop. Unfortunately weather records do not always supply data for limited areas and are often difficult to transpose into usable information.

In resorting to the climatological data it was found that no period of prolonged rainfall occurred in May and June during the period when the mast data were collected and no yearly correlation was obvious. On a state-wide basis two factors apparently had some bearing on fruit production; these were the minimum temperature and the per cent of weather stations that had at least one record of 32 degrees or below during May. These factors appeared to be somewhat related. The lower the minimum temperature at any station in the state the larger the percentage of stations having at least one night of frost. The data indicated that when only a small per cent of the stations had a temperature of 32 degrees or below, these stations were usually in high elevations in the eastern part of the State.

A definite correlation was found when comparisons were made between the lowest temperature at any station in the State and the group mast index. This comparison was also made for two regions (Regions 1 and 2) and a similar correlation was obvious.

Sometimes discrepancies exist but often can be explained when a thorough study is made. According to comparisons made the 1948 Group A mast index should have been higher when compared to the climatic data collected. This was primarily due to the failure of the Black Oak Group, which apparently was affected the previous year by state-wide frosts lasting as much as six consecutive nights. Although the minimum temperature (below 32°) in May 1945 was higher than in 1949, the mast index was higher for the latter year. The data indicated, however, that the frosts were more widespread in 1945 thereby accounting for the lower mast index. These are examples of the pitfalls that might occur if detailed scanning of the data is not made. Differences are not always obvious.

Correlation with the Wild Turkey Kill—

It was interesting to note that the highs and lows of the wild turkey kill followed reasonably close to the highs and lows of the mast index. The years showing a low kill coincided evenly with those having subnormal temperatures in May and a low mast index. Figures 2, 3, and 4 show this correlation for

Figure 2. State-wide Mast Index and Turkey Kill.

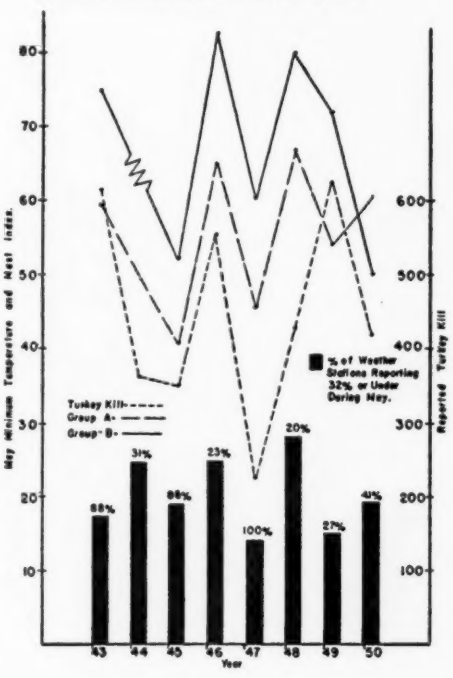
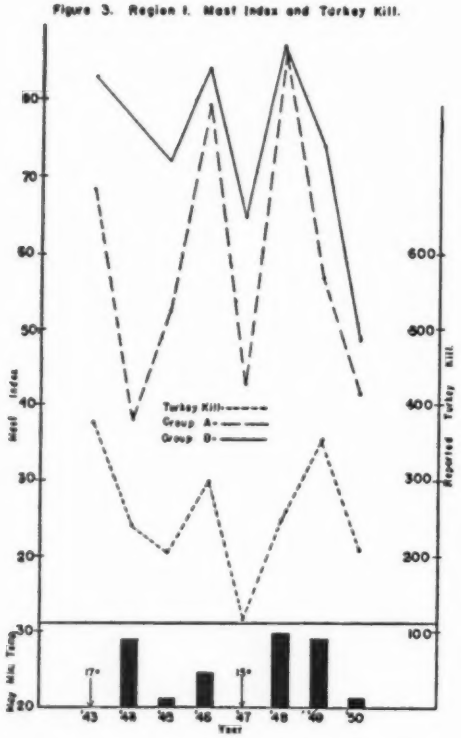


Figure 3. Region 1. Mast Index and Turkey Kill.

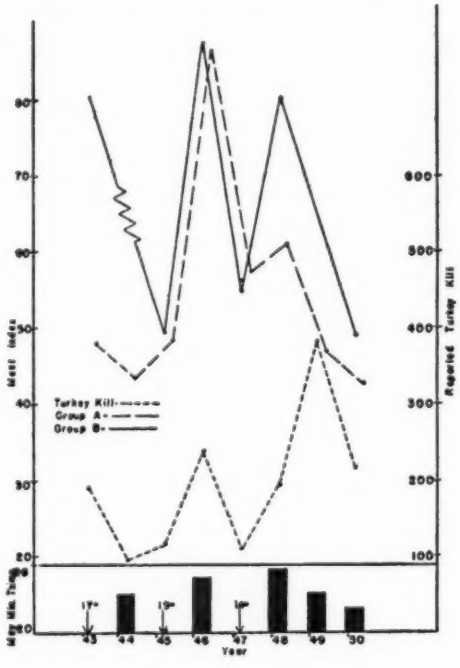


Regions 1 and 2 and state-wide. These two regions were selected as illustrations because they contain over 80 per cent of the total turkey population.

It has already been pointed out that the mast index is dependent to a great extent on the minimum temperature in May. The graphs would, therefore, indicate that the turkey kill was possibly dependent on the mast supply or the temperature. It is believed that the first two items are either directly or indirectly dependent upon the third factor.

It is unknown to what degree low temperatures are detrimental to young poults at the time of hatching. The dates for the various nesting activities as calculated by Mosby and Handley (1943) lead to the possible conclusion that below freezing temperatures in May, when the bulk of the turkeys are hatching, might be detrimental. Although temperatures were low in May 1943, the turkey kill the following fall and the mast index were above normal. The weather records show, however, that the low temperature occurred on the first two days of the month possibly before flowering occurred and before the primary period of the turkey hatch. It is shown in the graphs that low temperatures were recorded in 1945. These were almost state-wide. The turkey kill was low the following fall. In 1947 an all-time low of 14°F was recorded as well as a continuous freeze for six consecutive nights. Reported kills since 1940 indicated that the kill in the following fall was the lowest on record and the mast index was the second lowest. The only extreme exception in the correlation be-

Figure 4. Region 2. Mast Index and Turkey Kill.



tween the mast crop and the turkey kill was in 1949 when the mast index dropped and the turkey kill continued to rise. The turkey survey was going on at that time which probably resulted in more reports of kills from the sportsmen. Although the correlations given are quite apparent to those working with the material, it is not intended that this paper convey the impression that the fruiting of plant species and the annual turkey kill is controlled by minimum temperatures in May alone. Other factors undoubtedly have their effect, perhaps even more than temperature. Temperature is perhaps one of the more obvious tools that can be used either alone or together with some other climatic factor.

Unfortunately kill figures for other wildlife species are not available for comparison. It is felt that if these figures were available some interesting comparisons could be made either on a state-wide basis or by regions.

SUMMARY

1. A method was derived for obtaining a broad annual mast index.
2. The state was divided into regional divisions on the basis of ecological factors.
3. A correlation was found between mast index, reported turkey kill and minimum temperatures in May. The correlation was obvious not only on a state-wide basis but also on a regional division.
4. It is felt that the method of regional division and correlation could be applied to other investigations.

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THE WILDLIFE SOCIETY

Report of the Secretary for the Year 1951

Work of the Secretary through the past year consisted of recording payments for dues, subscriptions and orders of back issues of the Journal of Wildlife Management and the Ten-Year Cumulative Index to the Journal; the placement of orders for all these items with the publisher; making changes of address for members; sending out membership application blanks to Regional Representatives, members of the Membership Committee, prospective members, and other interested parties; invoicing subscribers and others for publications; the compilation of a Society Membership Directory; answering inquiries from a wide variety of sources relative to the Society and its work; mailing out ballots on proposed Constitutional Revisions, the nomination of Regional Representatives for 1952, and election of Society officers for 1952; the tabulation of returned ballots; and numerous other miscellaneous details.

Total membership figures for the Society remain about the same as for 1950, despite the combination of membership classes and a uniform assessment of $5.00 for annual dues. As of December 31, 1951, there were 1,726 paid members and eight Honorary Members. Of the paid members, 203 were new ones whose membership began after the opening of school last fall. At the close of 1951, there were 335 subscribers to the Journal of Wildlife Management, representing all of the 48 States, Alaska, Hawaii, Canada, Australia, Belgium, Brazil, British West Indies, Burma, China, Denmark, East Africa, England, Finland, France, India, Indonesia, Italy, New Zealand, Philippine Islands, Puerto Rico, South Africa, Sweden, and U.S.S.R.

It is of interest to note that as of February 29, 1952 (close of the Society year), there were 1,414 paid members and 317 subscribers. The members so listed include 123 new ones. There still are approximately 430 old members who have not covered dues for 1952; and 74 subscribers have not renewed for this year. Seven members resigned during 1951, giving no reasons for their withdrawal.

The known loss of five members through death is regretfully reported; their names, places of residence and dates of death being as follows: Paul Bonnot, Menlo Park, California, August 1, 1951; Dr. J. Lee Deen, Fort Collins, Colorado, April 24, 1951; Dr. Herbert L. Dozier, Lafayette, Louisiana, December 4, 1951; Gus A. Engeling, Palestine, Texas, December 13, 1951; and Dr. J. Southgate Y. Hoyt, Cornell University, Ithaca, New York, June 1, 1951. Notices of these losses have been forwarded to the Committee on Memorials. The Secretary urges that information on other deaths be forwarded to him by the membership.

Ballots were mailed to all members relative to Constitutional Amendments proposed at the 1951 Council and Society Meetings, providing that: (1) votes of members *present* at any business meeting shall decide new Honorary Members, (2) all classes of members shall be eligible to represent the Society *when so appointed by the President or the*

Council, (3) the majority *of those voting* shall decide the outcome of any election or other balloting, (4) Life Members may pay $100 in a lump sum or *not less than $25.00 per year over a period not to exceed four years,* (5) the President and Vice President shall be *eligible to succeed themselves for a period not to exceed a total of three consecutive terms of one year each,* (6) the Secretary *shall take office* in each odd-numbered year, (7) the Treasurer *shall take office* in each even-numbered year, (8) a Council member *may appoint a qualified member to represent him as an alternate to the annual Council meeting provided he so advises the President in advance,* (9) the Council may *direct that meetings other than annual business meeting be held,* (10) resolutions must *receive a majority approval of the Council before being proposed to the Soceity,* (11) a two-thirds vote of members *who return ballots* will be sufficient to amend the Constitution, (12) Regional Representatives will be *nominated and elected annually by mail ballots,* (13) the fiscal year of the Society shall end *the last day of February.* All amendments proposed last year were passed by a majority vote and were incorporated in the Constitution as printed in the January 1952 issue of the Journal of Wildlife Management.

The Nominating Committee for 1951 proposed officers for 1952 as follows: President—Daniel L. Leedy and D. I. Rasmussen; Vice-President—Paul D. Dalke and Harlow B. Mills; Treasurer—E. L. Cheatum and Arnold B. Erickson. In the balloting on these nominees, the winners were: Daniel L. Leedy, President; Paul D. Dalke, Vice President; and E. L. Cheatum, Treasurer.

Mail balloting for the nomination of Regional Representatives resulted as follows: Region I—Durward L. Allen and Roger Latham; Region II—Arnold O. Haugen and E. E. Hueske; Region III—Thomas R. Evans and T. A. Schrader; Region IV—Fred Johnson and Levi Mohler; Region V—F. M. Baumgartner and W. B. Davis; Region VI—Arthur S. Einarsen and Starker Leopold; Region VII—Ian M. Cowan and C. David Fowle. Election ballots on these nominees will be mailed as soon as the printer can prepare them.

Upon request, Cayuga Press Inc., prepared an inventory of publications on hand as of February 15, 1952. This report reveals a very low stock of certain issues of the Journal of Wildlife Management. There is an active demand for back issues on the part of members, subscribers, libraries, and other agencies. As of the date of inventory, there were still 1,052 copies of the Ten-Year Index in stock.

The Secretary wishes to extend to Mr. Shaler E. Aldous his thanks for counsel on secretarial responsibilities through the past year. He also acknowledges with gratitude the activity of Regional Representatives in soliciting new members, and the ready responses of the entire Council to requests for decisions relative to Society business. Special recognition is due Mrs. Martha W. West, assistant to the Secretary, for her constant and dependable help in keeping even approximately abreast of the flow of correspondence.

Respectfully submitted,

W. C. Glazener, *Secretary*

March 17, 1952

REPORT OF THE TREASURER FOR THE FISCAL YEAR JANUARY 1, 1951 TO FEBRUARY 29, 1952 (14 months)

I am pleased to submit herein, the annual report of the Treasurer of The Wildlife Society. This report deals with the fiscal year January 1, 1951 – February 29, 1952. Due to Constitutional change, this particular fiscal year comprises fourteen months.

EXHIBIT "A", consists of and presents a statement of Receipts and Disbursements.

Disbursements were reconciled to the checks issued by the Treasurer and as of February 29, 1952. The following checks were outstanding on that date:

Date	*Check No.*	*Payee*	*Amount*
February 19, 1952	117	Science Library U. of Manitoba	$1.50
February 28, 1952	120	John D. Gill	1.00
			$2.50

The following represents the Bonds, Common stocks, Fidelity Bond, and Insurance Policies:

United States Savings Bonds, Series "G", maturing in 12 years from the date of issue, and bearing interest at the rate of 2½ per cent per annum:

Bond Number	*Date Issued*	*Cost*	*Redemption Value at 2/29/52*
D2576621 G	April 1947	$500.00	$474.50
D2576622 G	April 1947	500.00	474.50
D2943626 G	September 1948	500.00	473.50
D2943627 G	September 1948	500.00	473.50
		$2,000.00	$1,896.00

COMMON STOCKS:

	Date Issued	*Certificate Number*	*No. of Shares*	*Cost*
Loomis-Sayles Mutual Fund, no-assess & without par....	6/25/48	2950	30	$992.70
State Street Invest Corp. no-assess & without par....	1/8/48	C95210	22	979.00
Current Value: Loomis-Sayles — 30 shares				$1136.10
State Street — 22 shares				1441.00

FIDELITY BOND:

Fidelity Bonds on the Treasurer of the Society are carried with the Yorkshire

Indemnity Company of New York. Bond Number F-49229 in the amount of $10,000.00 is in force.

INSURANCE POLICIES:

Insurance on Journals at Cayuga Press, Ithaca, New York are carried with The Continental Insurance Company as follows:

Policy No.	*Expire Date*	*Amount*	*Coverage*
12135	5/5/52	$6,000.00	Fire and E C
SL26390	5/5/52	6,000.00	Sprinkler leakage

The two policies carry a 90% co-insurance clause.

COMMENTS:

Through Council action and Membership approval, the fiscal year was altered. This fiscal year accordingly comprised fourteen months. The budget involved took into consideration the additional issues of the Journal and Newsletter.

On the date of the submission and presentation of this Financial Report, the costs of printing and mailing the February issue of the Newsletter were not received. Accordingly, the Fiscal Year Expenditures for this item reflect the costs of printing and mailing of only four (4) issues of the Newsletter. Approximately $200.00 should be added to the amount shown in Exhibit "A" to reflect the true cost of the Newsletter for the fiscal year.

For the second time, this Treasurer has reported the failure of the Council and Trustees in moving towards investing any part of the liquid checking balance in the Trust Fund. 1948 was the last action towards this, and in accordance with the Constitution and By-Laws of the Society, it is strongly recommended that action be taken.

The Treasurer transferred $8,000.00 from the liquid checking account to a Savings Account.

EXHIBIT "A":

STATEMENT OF RECEIPTS AND DISBURSEMENTS
FOR THE YEAR ENDING FEBRUARY 29, 1952

RECEIPTS:

Balance January 1, 1951		$13,104.84
Dues	$11,279.04	
Subscriptions	2,504.25	
*Back Issues	1,916.10	
Index	468.00	
Interest	434.74	
Nebraska Overrun	194.00	
Overpayments	25.06	
Payment on Life Member	25.00	
		16,846.19
		$29,951.03

* Add $1.25 received in U.S. Postage & turned over to secretary

DISBURSEMENTS:

		ENCUMBERED
JOURNAL (5 Issues):		
Printing & Mailing	$ 7,069.68	$ 1,727.25**
Mailing Back Issues	336.83	
Insurance on Stock	44.40	
	7,450.91	1,727.25
NEWSLETTER (5 Issues):		
Printing	838.52	
Mailing	375.87	
	1,214.39	
PRINTING:		
Ballots, Elections, Dues	402.28	
Stationery	89.64	
Directory	363.86	
Directory (Mailing)	152.48	
Reprints	14.81	
EXPRESS:		
Secretary Records	109.94	
Journals to New Publisher	308.38	
	418.32	
Postage: Editor, Secretary, Treasurer	180.50	
Leopold Medals (Incl. Sculptor)	844.75	
Office Equipment	35.05	
Clerical Assistance	13.75	
Editor's Expenses	24.50	
Treasurer's Bond	25.00	
Refunds, Bank Charges, etc.	34.79	
Contributions	165.00	
Miscellaneous	11.81	
Conference Expenses	43.32	
	11,485.16	1,727.25**
TRUE COST FISCAL YEAR:		$13,212.41

RECEIPTS:	$29,951.03
EXPENDED:	11,485.16
BALANCE: (Feb. 29, 1952)	$18,465.87

**Paid out after closing books February 29, 1952

ACCOUNTABLE AS FOLLOWS:

CASH BALANCE IN CHECKING ACCOUNT..... The Wildlife Society Fulton National Bank Atlanta, Georgia	$10,345.47
CASH BALANCE IN SAVINGS ACCOUNT..... The Peoples Bank The Wildlife Society Atlanta, Georgia	8,120.40
	$18,465.87

Respectfully Submitted,

WALTER A. GRESH, *Treasurer*

REPORT OF THE BUSINESS MEETING OF THE COUNCIL

The Council convened at 6:30 P. M. on March 16, in the McAllister Hotel, Miami, Florida. Council members in attendance were Warren W. Chase, President; Daniel L. Leedy, Vice President; Walter A. Gresh, Treasurer; W. C. Glazener, Secretary; Lansing A. Parker, Acting for Region I; Leonard E. Foote, Representative for Region II; Thomas R. Evans, Representative for Region III; Lee E. Yeager, Representative for Region IV; W. B. Davis, Representative for Region V; and Ben Glading, Representative for Region VI.

Items of business discussed and passed on by the Council are reported herein, in brief form.

The Council approved appointment of an Executive Secretary as provided by the Constitution, to be effective at the close of the next annual business meeting, with a budget of not more than $600 per year to cover clerical help.

The Constitutional Revisions Committee was authorized to study the problem of streamlining Society operations, including balloting, with a view to complementing the combination of the Secretary and Treasurer.

The Secretary and Treasurer were authorized to weed out old file material of no further active use, and the President was authorized to appoint an Archives Committee to go through all old records over three years old for the purpose of recommending their disposition at the next annual meeting.

The Council approved an item of not more than $50 to set up an employment desk at the next North American Wildlife Conference, as a service to members.

Gustav A. Swanson was re-appointed Editor of the Journal of Wildlife Management for 1952, with authority to print 2,700 copies of each issue of the Journal. He was further instructed to exercise his judgment in the selection of paper and a method of binding the

Journal, the subsequent issues to be mailed in envelopes rather than wrappers.

Henry S. Mosby was re-appointed as Editor of the Newsletter. The Council recommended that he investigate a less expensive method of producing the publication, possibly by multilithing.

The Council approved unanimously the listing of Volume 13 of the Journal (1949) at $8, because the stock is almost exhausted.

Mr. Charles B. Belt was appointed as Trustee to serve until 1955; he succeeds W. L. McAtee, whose term expired this year.

The Council approved Society affiliation with the Natural Resources Council, including the payment of $50 for such affiliation.

A motion that the Society withdraw affiliation with the International Union for the Protection of Nature failed to pass.

A proposal to send free copies of the Journal of Wildlife Management to "hard up" countries was defeated.

The Council approved a budget of $11,195.00 for the period of March 1, 1952 – February 28, 1953. This will cover printing of four issues of the Journal (not more than $9,000.00) and the Newsletters (not more than $600.00), and other costs including reprints, stationery and printing, postage, express, office equipment, clerical assistance, editors' expense, contributions and unforseen contingency expenses.

Payment of $50.00 to Mrs. Martha M. West was authorized as a token of appreciation for clerical assistance to the Secretary for the past year.

The Council approved transfer of $8,000 from current savings account to the Trustees for investment.

The question of a Wildlife Society Library Collection was deferred for further discussion by the membership through the coming year.

By unanimous consent, the Council approved E. R. Kalmbach, Harrison F. Lewis, and Walter P. Taylor as Honorary Members, subject to Society confirmation.

Resolutions presented by the Resolutions Committee were acted upon; those approved by the Council will be presented by the members at this annual business meeting.

Respectfully submitted,

W. C. GLAZENER, *Secretary*

MINUTES OF THE ANNUAL MEETING OF THE WILDLIFE SOCIETY

The sixteenth annual business meeting of the Wildlife Society was called to order by President Warren W. Chase at 8:00 p.m., March 17, 1952, in the McAllister Hotel, Miami, Florida. Approximately 130 members were in attendance.

Reading of the 1951 minutes of the Council and business meetings was dispensed with because both were published in the July 1951 issue of the JOURNAL OF WILDLIFE MANAGEMENT. The minutes of both meetings were approved as printed.

The report of the Secretary and the minutes of the 1952 Council meeting were read and approved. This included the recommended budget for the coming year.

The Treasurer's report was read, and

on recommendation of an auditing committee was approved. The committee consisted of E. L. Cheatum, J. R. Langenbach and A. M. Stebler.

Regional and Sectional reports were read or summarized and approved as given. They are included separately hereafter, as submitted. Henry S. Mosby reported that the Virginia Section of the Society had disbanded.

The President appointed a balloting committee consisting of Frank W. Blair, E. A. Walker and A. J. Springs, to audit all ballots for 1951-1952.

The matter of publication of Proceedings of the Southeastern Section was raised by O. E. Frye. The Society held that this was a question to be decided by the Section and its membership.

The Society approved, by unanimous vote, the designation of E. R. Kalmbach, Harrison F. Lewis and Walter P. Taylor as Honorary Members; the action being in recognition of the long service and outstanding contributions of these men to the cause of wildlife management.

The resolutions committee presented two resolutions that were passed, as follows: (1) that the Society urge the Congress to provide a suitable portion of the range of the key deer as a permanent refuge for the species, and (2) that the Society express all due thanks to the Wildlife Management Institute and other cooperating organizations and individuals for their efforts contributing to the success of the Conference.

It was unanimously voted to revise By-Law IV to the effect that members in the armed services be allowed to secure missed back issues of the Journal at regular cost.

Reports submitted by certain committees were approved, those reports being presented separately hereafter.

It was voted to submit to the membership a constitutional amendment providing for appointment of the Membership Committee by the President. This amendment will be submitted by mail ballot at a later date.

The Society gave a standing vote of thanks to Walter A. Gresh as an expression of appreciation for his excellent work as Treasurer for the past two years.

Respectfully submitted,
W. C. GLAZENER, *Secretary*

ANNUAL REPORT OF REGION I OF THE WILDLIFE SOCIETY

The Northeast Section of the Wildlife Society had another successful year. It is evident that the Section is serving a growing function in bringing together people in the Northeast who have a common concern with wildlife and its management.

The outstanding event of the year, as might be expected, was the annual meeting held at Wilmington, Delaware, 23 to 25 February, 1951. This was referred to in last year's report.

This year the annual meeting is to be held April 1 to 3 in West Virginia at Jackson's Mill, the boyhood home of General Stonewall Jackson. Jackson's Mill is described as the pioneer 4-H Camp in the United States. It is situated deep in the West Virginia hills and is ideally suited to this meeting. Under the

chairmanship of Charles O. Handley and with the help of an active program committee, an amazing volume of inviting propaganda has been issued. Widespread interest and plans for attendance promise another successful meeting.

We have been carrying on a membership campaign in the Northeast. The Secretary of the Society evidently has heard from some of those tapped, for I have had an indignant protest against my cordial invitations to men who already were members but whose names did not appear on our superannuated membership list. As a result, I am for an annual up-to-date membership list in spite of the cost.

Respectfully submitted,
Durward L. Allen,
Regional Representative, Region I

1951-52 NORTHEAST SECTION—WILDLIFE SOCIETY ACTIVITIES

Since presenting a summary of the yearly activities, in Milwaukee, Wisconsin, in 1951, the Northeast Section of the Wildlife Society has continued to be very active under the able Chairmanship of C. O. Handley of West Virginia.

This year, the Northeast Section is not able to present any report of our Wildlife Conference, for our meeting is to be held on April 1 thru 3, at Jackson's Mill, West Virginia. The 1952 conference will be a joint meeting of the Northeast Sections of the American Fisheries Society and the Wildlife Society.

The agenda provides for a joint meeting of the two organizations on the first day and each group having their respective sessions, running concurrently on the following two days.

It is anticipated that the meeting will draw a capacity attendance.

A general resumé of the Section's activities for the year are as follows:

I *Conferences* (1951-52)
1. 350 in attendance at the 1951 conference in Wilmington, Delaware.
2. Complete conference transactions made available to members.
3. Two issues of a Section Newsletter.
4. Plans for a joint conference with fisheries group for 1952.

II *Section Status*
1. Present Section Membership at 300 plus.
2. Officers: C. O. Handley, Chairman
   R. Mc Dowell, Vice Chairman
   P. Barske, Secy.-Treas.
3. Executive Committee: D. Allen, N. G. Wilder, W. Sheldon, F. Johnson.

III *General Activities*
1. Study Committees to report on:
   a. Status of Wildlife Research in Northeast.
   b. Professional status of Wildlife Technicians.
   c. Training of Wildlife Technicians.
   d. Northeastern Youth Conservation Camps.
2. Membership Drive.

Respectfully submitted,
PHILIP BARSKE, *Secy.-Treas.*,
Northeast Section, THE WILDLIFE SOCIETY

ANNUAL REPORT OF REGION IV OF THE WILDLIFE SOCIETY

Activities undertaken by the Wildlife Society in Region IV, regardless of year or the times, are governed, in part, by the vast area of the seven states involved. Only Region VII, Canada, is larger. The 250 odd members of the Society residing in Region IV are widely separated, even though a considerable number of them are concentrated in the Denver–Fort Collins and Billings, Montana, areas.

Despite the factor of distance, however, several partial get-to-gethers of the regional membership occurred last year. The most important was the two-day Game Management meeting of the Colorado Game and Fish Department, Denver, April 9-10. On this occasion, Society members, foresters, and range management personnel, in a joint meeting, staged a spirited discussion of the need for coordinating conservation programs and activities. Dr. Tim K. Kelly of the University of Colorado led this discussion, and was ably supported, and in some instances opposed, by the numerous well-known members of the Society, and others present: E. R. Kalmbach, Dean J. Lee Deen, Prof. J. V. K. Wagar, John D. Hart, Gilbert N. Hunter, Regional Forester Edward Cliff, Ralph R. Hill, H. E. Schwan, several Forest Supervisors, two members of the Colorado Game and Fish Commission, and visitors. A similar meeting is planned for 1952.

Mr. E. R. Kalmbach officially represented the Wildlife Society at this meeting, in view of the writer's enforced absence.

Another meeting of interest in Region IV was the annual Foresters' Day program at Colorado A & M College, Fort Collins, February 23, 1952, where the Society was represented by members from five of the seven states. No formal Society program was scheduled on this occasion, but the Foresters' and Range Management Society's programs, followed by a joint program featured by an address by J. Alfred Hall, Director of the Forest Products Laboratory, was of interest to all.

Although no final plans have been matured, there is a movement favoring the organization of a section of the Society in Region IV. The present lack of a sectional group adds to the difficulty of holding formal meetings when a portion of the Regional membership gathers on special occasions, usually in connection with forestry, range management, or similar conferences. It is anticipated that initial steps toward organization will be taken in April, 1952.

Finally, the undersigned is appreciative of the assistance given by the membership during the year. In this respect, E. R. Kalmbach, R. R. Hill, J. V. K. Wagar, and Harold W. Steinhoff, were particularly helpful.

Respectfully submitted,

LEE E. YEAGER, *Regional Representative, Region IV*

ANNUAL REPORT OF REGIONAL REPRESENTATIVE, REGION V 1951-52

In addition to the numerous duties befalling a member of the Council, your representative made a special effort to increase membership and interest in the Wildlife Society. Key members in Arizona, New Mexico, Oklahoma and Texas were urged to make an intensive drive in their respective states for new members, contacting all personnel of conservation agencies (law enforcement officers, biologists and administrators) as well as students and others interested directly or indirectly in any phase of wildlife conservation and management. Although only 20 new members joined the Society in Region V in the past year, continued efforts should increase the regional membership as much as 30% in the coming year.

One activity sponsored in part by your representative resulted in a large representation of wildlife management students (some 16) from Texas at the North American Wildlife Conference at Miami. Through his efforts a local motion picture exhibitor permitted the Student Fish and Game Club at Texas A. and M. to sponsor a show at a drive-in theatre on which the students realized a profit of nearly $100. This money was used to defray part of the costs of attending the conference.

Respectfully submitted,

W. B. DAVIS, *Representative, Region V*

ANNUAL REPORT OF REGION VII OF THE WILDLIFE SOCIETY

Region VII is the largest region within the organization of the Wildlife Society, comprising, as it does, the whole of Canada. It extends from Atlantic to Pacific and northward into the Arctic over an area of some 3,600,000 square miles. About 80 of the 14,000,000 inhabitants of Region VII are members of the Society.

The Canadian membership is widely scattered from the Northwest Territories, where we have two members, and throughout all the provinces except Prince Edward Island. Almost 60% of the members live in British Columbia and Ontario, about 25% in the Prairie Provinces and the remainder in the Maritimes, Newfoundland and the Northwest Territories.

While the individual members derive the benefits of voting privileges and a subscription to the journal, there is little opportunity for developing other values from regional meetings such as we hear about in other regions. A circular letter from the Regional Representative is in the mail on its way to Canadian members, asking for suggestions for the establishment of a regional organization. Such an organization might be centered around a Canadian Newsletter, if there were sufficient interest to sustain it. With some increase in membership it will soon be possible, in British Co-

lumbia and Ontario at least, to hold periodic meetings of provincial groups to discuss the business of the Society.

While Canadian membership is small in comparison with that of the United States, many Canadian members may be envied by their American friends. Some of us may have the most interesting wildlife jobs in the world, living, as many of us do, in an environment where the timber wolf, fisher, lynx, wolverine, Arctic fox, musk-ox, moose, ptarmigan, grizzly bear and flocks of breeding waterfowl are still important elements in the fauna. We are also blessed with some land that is still real wilderness, unaltered by the hand of man. However, these facts in themselves suggest that our professional responsibilities are proportionately heavier, since we are not only faced with the problems of maintaining these resources in perpetuity, but most also cope with the increasing demand for wildlife in the face of increasing habitat destruction and encroachment on our wilderness areas.

During 1951 the trend begun a few years ago continued. Federal and provincial agencies are increasing their staffs of trained biologists and student interest in universities is sustained. What is probably more important is the trend towards a closer working relationship between the sportsmen and the technical men. In a number of instances, sportsmen's organizations have asked for guidance in their programs or have met with the biologists to discuss problems of mutual concern.

The Wildlife Society will learn with regret that Dr. Harrison F. Lewis, Chief of the Canadian Wildlife Service, has announced that he will retire this spring. Dr. Lewis has served his profession with distinction and it is a source of pride, not only to Canadian members but to the whole Society, that he has done so much to develop the Canadian Wildlife Service. His work with wildlife problems of international scope has been particularly outstanding. Throughout his career Dr. Lewis has, by his own example, set a high standard of professional integrity. All the members of the Society will join those in Region VII in wishing Dr. Lewis many years of health and happiness.

Respectfully submitted,

C. DAVID FOWLE, *Regional Representative*, March 8, 1952

REPORT OF THE COMMITTEE ON NOMENCLATURE

March, 1952

Your Committee on Nomenclature undertook three major tasks during the past year.

The Nomenclature Committee was asked by President Chase to aid in the formation of a policy relative to the uniform recording of deer dentition in papers to be published in the JOURNAL OF WILDLIFE MANAGEMENT. An article by Thane Riney (15(1):99–101) pointed to the necessity for a uniform, accurate expression of the dental formula in white-tailed deer.

Noncommittee members, namely Drs. Emmet Hooper, Remington Kellogg, C. H. D. Clarke and D. F. Hoffmeister

were asked to express an opinion on this problem to help guide the Society committee's action. As a result, six opinions were received, three from the committee and three out of four from the mammalogists consulted.

The concensus of opinion favored expressing the dental formula as follows:

$$\text{I } \frac{0}{3} \text{ C } \frac{0}{1} \text{ PM } \frac{3}{3} \text{ M } \frac{3}{3}$$

and the formula for individual teeth as

$$\text{I } \frac{000}{123} \text{ C } \frac{0}{1} \text{ PM } \frac{234}{234} \text{ M } \frac{123}{123}$$

It is recommended that these formulae be adhered to for all publications of the JOURNAL OF WILDLIFE MANAGEMENT requiring such formulae.

The method of field recording in deer research is a matter to be decided upon by the persons in charge and is of no concern to the Nomenclature Committee. However several excellent suggestions were received in the course of this investigation which may be of value to the field worker.

Unless a precise dental formula is required, deer teeth could be designated by cheek, molariform, incisiform, front, fore, rear, and back, and could be numbered accordingly. This would present a topographic picture understandable to technician and layman alike.

Dental formulae that might be used by other workers in wildlife management and allied fields and which are to be published in the JOURNAL OF WILDLIFE MANAGEMENT should follow the descriptive formulae listed above.

Secondly, this year's Committee received from its predecessor the beginnings of what might eventually become a glossary of terms for the field of wildlife management. After a thorough examination of the materials on hand and an evaluation of the task ahead, the following recommendation has been approved by the entire committee: *That a committee of the Society charged with the compilation of a glossary of terms for the field of wildlife management be a standing committee, its tenure to be terminated when the task at hand is completed and accepted by the Council.* If this recommendation is accepted the present committee will give the President the benefit of its thinking on this problem. The committee files which contain many fine ideas, plus the names of members who were considered to have special interest or qualifications along these lines, will likewise be placed at his disposal.

Lastly, we attempted to evaluate the Nomenclature Committee's contributions, past and present, to the Society. Since its inception, the Committee's accomplishments have been meager indeed. Therefore, it is recommended *that if the glossary compilation is placed in the hands of a standing committee, the present Nomenclature Committee should be dissolved.* All incidental chores could then be allocated to the standing committee without great encumbrance.

In any event, a committee dealing with terminology and semantics should be called a Committee on Terminology rather than a Nomenclature Committee since it will not be dealing with names in a taxonomic sense. The directive by which this committee was set up specified that the committee title be "a Terminology Committee" (Journal

of Wildlife Mgt., July 1948, p. 323).

This report represents the ideas and efforts of your 1951 Nomenclature Committee in fulfilling its obligations to the Society.

VERNON C. APPLEGATE
E. L. CHEATUM
JESSUP B. LOW
ARNOLD L. NELSON
ROBERT A. MCCABE, *Chairman*

REPORT OF
AWARDS COMMITTEE, TERRESTRIAL PUBLICATIONS, 1950-1951

In selecting the recipient of The Wildlife Society's annual Award for the outstanding terrestrial publication for 1951, the Committee reviewed many books, bulletins, and shorter papers in this field. In addition, several nationally known wildlife authorities, both American and Canadian, were consulted and their opinions on the literature under consideration were available to the several Committee members. Every effort was made to canvass the field thoroughly and to make the selection on a completely deliberate and objective basis.

The book, "The Elk of North America", by Dr. O. J. Murie, was unanimously selected as the outstanding terrestrial publication in 1951. In making the selection, the Committee was governed by the quality and originality of the work, its application in the broad field of wildlife management, its coverage of the subject, and its effectiveness in presentation. All of these criteria were achieved to an outstanding degree in the selection made.

Notwithstanding Committee unanimity in selecting the outstanding 1951 Terrestrial Publication, there was considerable competition from the numerous other fine publications in this field. Outstanding among such works were the following books: "North American Waterfowl" by Albert M. Day; "American Wildlife and Plants" by Marten, Zim, and Nelson; "Wildlife Management" by Ira N. Gabrielson; "Practice of Wildlife Conservation" by Leonard Wing; and "The Clever Coyote" by Young and Jackson.

One book in the popular field was regarded by the Committee as worthy of commendation. This work, "Feathers Preferred", by W. Austin Peters, seemed so thoroughly imbued with the spirit of conservation and wise use of wildlife resources that the Committee felt that it should be distinguished in the great mass of popular literature.

It is the recommendation of the Committee that the above-named works be designated as *Honorable Mention* contributions to the literature of wildlife management and ecology.

Respectfully submitted,

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REPORT OF AWARDS COMMITTEE, FISHERIES PUBLICATIONS, 1950-51

The committee made an effort to cover the publications which appeared during the biennium thoroughly, and some half a dozen received favorable mention from one or more members. On the final ballot, Dr. Paul Eschmeyer's "The Life History of the Walleye, *Stizostedion vitreum vitreum* (Mitchill), in Michigan" received overwhelming endorsement. Published as Bulletin No. 3 of Michigan's Institute for Fisheries Research, it is a definitive report on the study which the Institute has given to this important sport and commercial species.

The Committee was also of the opinion that, if it had been instructed to select the *most useful* publication of 1950-51, the choice would have been Dr. Kenneth D. Carlander's "Handbook of Freshwater Fishery Biology." However, because it is not a record of original research, a majority of committee members felt that the Handbook was not in the field for which the Society's award was designed.

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SUPPLY AND DEMAND

REPORT BY THE WILDLIFE SOCIETY EMPLOYMENT COMMITTEE 1951

During the past several years the Employment Committee has reported on the number of wildlife students enrolled in the colleges, the number of graduates and their resultant employment. The past two years' surveys have been published in the JOURNAL OF WILDLIFE MANAGEMENT under the titles, "It's Time To Take Stock," 14(2):237–242 and "More Stock Taking," 15(3):317–322. Many members have expressed the desire to see the survey continued in order to present the current status and to provide a continuous record. The Committee extends its sincere thanks to the school representatives who returned the completed questionnaires. As an added assignment the Committee joined with the Professional Standards Committee in soliciting employment information from the State, Provincial and Federal agencies that employ fish and wildlife technicians. Of particular concern to this Committee was the immediate and long range personnel needs. The Committees are very grateful for the interest shown by the administrators.

THE SUPPLY

This year 63 colleges and universities in United States, Canada and Alaska were requested to furnish the information in substantially the same form as

last year. The institutions (See Table 1) include schools circulated in 1950 and an additional 17, most of which specialize in fisheries training. The fishery schools have never been thoroughly canvassed by previous Wildlife Society studies and it is possible that the present coverage is not complete. Replies were received from 52 institutions. Some give general biology, zoology, ecology or similar curricula, but offer no specific training in wildlife. These have been segregated in the table on the basis of information supplied by the school representative.

A large number of the schools do not offer degrees in fish, wildlife or conservation. "Wildlife majors" are variously interpreted and in many colleges the students do not declare their major until their sophomore, junior or even senior year. Therefore, the 1271 undergraduates and the 486 advanced students recorded this year represent figures for the minimum enrollment now present in the schools.

The number of fish and wildlife students continued to decline for the third consecutive year. For comparative purposes the enrollments have been tallied for the same 37 institutions reporting in 1950 and 1951. Last year there were 1295 undergraduates and 433 graduate students, totaling 1728 in these schools. This year there were 1205 undergraduates and 459 advanced students or a total of 1664. The 1951 undergraduate enrollment of all institutions was composed of 21 percent freshmen, 23 percent sophomores, 28 percent juniors, and 28 percent seniors. In 1950 the percentages were 21, 28, 25, and 26, respectively. In the 37 schools there was a 7 percent decline in underclassmen this year. However, in the same schools there was a 6 percent increase in the graduate students. The decrease may be attributed to one or several conditions. The G. I. students have practically all passed through the schools. The declining employment opportunities may have had a discouraging effect. The stepped-up military demands for manpower very likely took many students away.

Thirty-six of the schools reported that 486 advanced students were enrolled this year. These were divided into 345 working on master's and 141 for their doctor's degrees. In the institutions giving data for two years there was an increase of 26 or 6 percent. Thus the trend for more advanced degrees continues. A comparison of the ratios of undergraduates to graduates for the three years bears out this contention. In 1949 the ratio was 4.6 to 1, in 1950, 3.1 to 1, and in 1951, 2.6 to 1.

The number of students graduating in the school year ending September 30, 1951, totaled 495 as reported by 40 schools. This is a decided drop from the 633 recorded last year. They were divided as follows: 355 bachelor's, 137 master's and 23 doctoral degrees.

The schools also reported on the progress of the 1951 crop of graduates. Of the bachelor's, 117 or nearly 35 percent obtained fish or wildlife employment. This is a 10 percent drop in number from last year which also showed a similar decline from the year before. Almost one fourth of the class returned for further schooling, a decline of 4 percent. Military services claimed 10 percent or double last year's percentage. Two percent went into teaching; 8 percent landed in other types of employment while 17 percent were "un-

known" or unaccounted for. Nearly half in "other work" were employed in fields closely allied to wildlife, such as forestry, soil conservation, Boy Scouts and boys' camps.

Slightly over half (55 percent) of the master's obtained fish or wildlife employment which also represented a substantial decline from last year's 72 percent and 89 percent for 1949. Nineteen percent went back to school, 6 percent reported to military service,

TABLE 1.—DISTRIBUTION OF CLASSES BY SCHOOLS CIRCULARIZED DURING THE STUDY

School	Undergraduates					Graduates		
	Fresh.	Soph.	Junior	Senior	Total	Masters	Ph.D.	Total
Alabama Polytech	2	5	10	5	22	6	—	6
Alaska, Univ. of	4	6	3	1	14	8	—	8
Arizona, Univ. of	—	6	5	—	11	4	—	4
British Col., Univ. of	*	*	3	3	6	4	6	10
Colorado A. and M.	**	8	10	12	30	14	—	14
Conn., Univ. of (none rptd.)	—	—	—	—	—	—	—	—
Florida, Univ. of (1)	**	**	6	3(33)	42	21	17	38
Georgia, Univ. of	*	*	10	8	18	5	3	8
Humboldt State Coll.	25	15	17	22	79	—	—	—
Idaho, Univ. of (2)	—	—	—	—	—	5	—	5
Iowa State College	—	—	5	5	10	15	6	21
Louisiana State Univ. (2)	—	—	—	—	—	4	—	4
Maine, Univ. of	**	11	9	7	27	5	—	5
Mass., Univ. of	15	16	10	9	50	5	—	5
Mich. State College	16	12	32	24	84	21	11	32
Mich., Univ. of	8	9	13	15	45	14	17	31
Minn., Univ. of	***	***	***	***	45	4	0	4
Missouri, Univ. of	10+	15+	13	14	52+	12	6	18
Montana State Univ.	2	4	15	24	45	9	—	9
Mont. State Coll.	9	3	5	10	27	16	—	16
New Hampshire, Univ. of	**	4	2	6	12	—	—	—
N. Y. State Coll. of Agr. (Cornell)	25	12	8	15	60	12	16	28
N. Y. State Univ. (Syracuse) (2)	—	—	—	—	—	13	2	15
N. C. State College	12	6	8	8	34	3	2	5
Ohio State University	8+	9+	24	21	62+	11	8	19
Oklahoma A. and M.	6	9	11	9	35	12	10	22
Oklahoma, Univ. of	—	—	—	—	—	6	5	11
Oregon State College	22	42	39	35	138	25	—	25
Penn. State Coll.(2)	—	—	—	—	—	15	—	15
Purdue Univ.	—	2	1	—	3	3	—	3
San Jose State College	20+	15	8	5	48+	—	—	—
So. Dakota State College	7	7	10	6	30	—	—	—
So. Illinois Univ.	4	6	5	3	18	12	—	12
Texas A. and M.	23+	15+	16	14	68+	3	6	9
Toronto, Univ.of	*	3	—	2	5	9	10	19
Utah State College	14	8	17	19	58	19	3	22
Vassar College	—	—	—	1	1	—	—	—
Virginia Poly. Inst.	**	**	**	6	6	8	2	10
Wash. State College	15	16	9	11	51	4	1	5
William and Mary	**	**	**	**	**	4	—	4
Wisconsin, Univ. of	—	—	4	6	10	8	10	18
Wyoming, Univ. of	4	5	8	8	25	6	—	6
Totals (42)	251	269	336	337	1271	345	141	486

* Unknown.
** Not designated.
*** Not reported separately.
(1) Dept. of Biology reports 33 juniors and seniors
(2) No undergraduates in wildlife.

Continued on following page.

TABLE 1—(Continued)

Calif., Univ. of (Davis)	Courses offered for Zool. Majors and Agric. curricula							
Florida State Univ.	No course work, strictly marine							
Harvard Univ.	gen. ecology	4	13	25	42	2	5	7
Indiana Univ.	Limnology					3	2	5
Johns Hopkins	No undergraduates					—	7(Sc.D.)	7
Kansas, Univ. of (Zoology)	140	100	33	25	293	16	21	37
N. C., Univ. of	Wildlife work not carried on at N. C. Univ.							
Rhode Island, Univ. of	Zoology or Ecology majors							
Stanford Univ.	Train a few highly selected graduate students in fishery work					(none reported)		
Texas A. and M., Dept. of Ocean.	Offers advanced degrees in oceanography							

No replies from: Calif., Univ. of (Berkeley), Duke Univ., Illinois, Univ. of, Md., Univ. of, Nebr., Univ. of, Nev., Univ. of, Rutgers Univ., S. Calif., Univ. of, Temple Univ., Wash., Univ. of, Yale, Yankton State Col.

more than 6 percent commenced teaching, 11 percent found other employment and 3 percent were not accounted for. Nearly everyone of the graduates reported in other types of employment were working in closely related fields.

Teaching attracted more than half (52 percent) of the doctor's and slightly over one-third (35 percent) went into fish and wildlife jobs. Last year the teachers were not reported separately so that the figures are not comparable. Nearly 9 percent went into military service and about 4 percent were classed as unknown.

The breakdown by types of fish and wildlife employment for 209 graduates revealed that 93, or nearly 45 percent, went into game work; 67, representing 32 percent, entered fisheries activities; and 17, or 8 percent, were in a combination fish and game position. The percentage figures approximate those reported last year which were computed to be 49 in game, 35 fish and 4 percent in combination positions. Those engaged in law enforcement work totaled 13, representing 6 percent, and compared favorably to the nearly 7 percent last year. Seventeen, or 8 percent, were teaching wildlife courses. This is a considerable increase over the 4 persons, or 1 percent, a year ago. Two administrative jobs represented 1 percent, compared to 11, or 3 percent, in 1950.

The analysis of the returns on source of employment disclosed that, of a total of 213, the greatest number of graduates, 149, went into State and Provincial fish and game departments. Percentage-wise of the entire employment field they represent 70 as compared to 73 for the previous year. Federal agencies, including foreign assignments, amounted to 43, or 20 percent. There was a drop from the 62 individuals reported a year ago, but on a percentage basis the level remained about the same as last year's 19 percent. Private employment dropped considerably from 21, or 6 percent, to 4, or 2 percent this year. Teaching attracted 17, compared to 4 for 1950, or 8 and 1 percent respectively.

THE DEMAND

In cooperation with the Professional Standards Committee, the Employment Committee sent a joint questionnaire to each State and Provincial fish and game department, the Canadian Wildlife Service, the chiefs of the operations' branches of the Fish and Wildlife

Service, the Biology Division of the Soil Conservation Service, the Division of Wildlife Management of the Forest Service and the Alaska Game Commission. Replies were received from 47 States, 4 Provinces, and the federal agencies.

Of immediate interest is the question of current employment needs. Those agencies which responded and had definite plans for recruitment (to July 1952) have been listed in the February 1952 issue of the Newsletter. By way of summary the Committee found there will be 81 replacements, 79 new permanent and 133 temporary positions in the game field. The fisheries employment will amount to 42 replacements, 91 new positions and 90 temporary. The latter figure is definitely low because inadvertently no space was provided on the questionnaire to insert the estimated number of temporary positions. The warden or conservation officer requirements include 178 replacements and 79 new jobs. Another source of employment is in the education or public relations field. The administrators were also asked to include their estimated requirements in this field. In total there will be 9 replacements and 22 new positions.

Grouped by training there will be 160 permanent and 133 temporary game openings. The fishery field will require 133 permanent and 90 temporary employees. There will be a need for 157 conservation officers and 31 public relations or educational personnel. These figures are conservative when considering the entire employment picture for we did not attempt to learn the needs in the teaching field, or other State and Federal agencies and private enterprises that employ a limited number of fish and wildlife biologists. The 581 permanent positions might be increased by one-fourth to give a figure of about 700 for the total current needs.

Another phase that was explored is the long range outlook for trained wildlifers. The administrators, answering this question, indicated that the future is exceedingly bright. In the fishery field 46 predicted an increased need while only 8 indicated their needs will remain the same. The game phase is not as clearly optimistic for 30 indicated a long range increase, while 28 thought the needs will remain about the same. A similar situation exists in the warden field, for 27 administrators thought there will be an increase, 20 reported the same and 2 indicated a decrease. Interesting is the fact that only in this phase did any of the administrators forecast a decrease. The outlook for public relations specialists will be definitely favorable, 37 reported an increase, and 4 that it will remain the same.

With an encouraging employment situation what should a person have in the way of training and experience in order to be reasonably sure of a job? The administrators were requested to rank these factors in order of preference when applied to recruiting new technical employees. Quite naturally, personality, appearance, and specific type of experience are probably given major consideration when actually filling a position. However the administrators were given a choice of B.S. degree and no experience, B.S. and 1 year of technical experience, M.S. and no experience, M.S. and 1 year and Ph.D. with no experience. Separate answers were requested for research and manage-

ment positions. Not all replies completely answered all parts of the question so that it was necessary to reduce the data to a comparable basis in each grade. The total replies in each category were multiplied by a value of 5 for first choice, 4 for second and so forth. The sum of each category was divided by the potential total.

Expressed in percentages for research jobs the M.S. with 1 year of experience received 91 with only one person grading this class as low as third choice. The Ph.D. ranked second, scoring 81 with 8 replies in third place, 2 in fourth, and 4 in fifth. The M.S. with no experience and the B.S. with one year ranked approximately the same with 54.3 and 54.4 percent, respectively. The B.S. with no experience ran a poor fifth with only 24 percent.

When considered for management positions the M.S. with one year's experience greatly outclassed the field with 93 percent. The B.S. with experience followed, scoring 70 percent. Third choice was the Ph.D. having 58 and pressed closely by the M.S. with no experience at 53 percent. Again the inexperienced B.S. made the poorest showing, with 29 percent.

Considerable interest has been expressed in former years about increasing the employment base by encouraging the wildlife graduate to go into the conservation officer field. Just how well received by the administrator would such a candidate be? The answer to this question can be found in the analysis of the following compilation. The administrators were asked to rank the following applicants: non-college with no enforcement training, in other words, the "I have hunted and fished all my life" sort of applicant; a man having previous enforcement or police experience; a B.S. with wildlife training; and a B.S. with experience but not necessarily in enforcement. The answers were weighted as explained above. The B.S. with experience gained about 97 percent of the possible total and received 45 first choices, 3 seconds and 2 thirds. The B.S. with no experience ranked a poor second with 65 percent, followed by the man with enforcement experience receiving 57 percent. The candidate with only the interest ran a poor last, rating only 20 percent.

In the answers to the above questions it is very apparent that experience counts heavily with the administrators. Further evidences of this are the replies given to the question of whether or not the administrators favored requiring summer experience as a part of training of the wildlife student. Fifty-seven of the 64 replying to the question favored that requirement. Only six answered in the negative and one was questionable.

Faced with the problem of gaining experience just what are the employment possibilities for the average graduate? Of 61 replies to the question of their employment policies, 36 administrators indicated they employed at a minimum level of experience and promote from within their organization. Another 16 indicated they hire both inexperienced and experienced personnel and 9 are hiring only experienced men. The replies to this question may appear to contradict the results of the questions cited above. However, it can be reasonably assumed that the administrators are faced with an immediate problem of recruiting personnel with no experience yet desiring experienced men.

CONCLUSIONS AND RECOMMENDATIONS

While the total enrollment of fish and wildlife students cannot be reported accurately or compared directly with last year's figure, there is a definite decline. For the 37 institutions reporting both years, there were 1728 in school last year compared to 1664 this year. However, there is an increase in the higher grades and in the graduate schools. Thus the wave of heavy student enrollment following the war has now reached the end of its surge. The military requirements will continue to suppress enrollment as long as world conditions remain critical. Ten percent of the B.S. graduates and 6 percent of the M.S. and 9 percent of Ph.D., or approximately 11 percent of all of the graduates entered military service this year.

The number of recorded graduates this year declined from 633 last year to 495. The figures are not directly comparable because of the difference in the institutions' reporting. The State, Provincial, Federal and Alaskan fish and wildlife agencies estimated that between September 1951 and July 1952 there will be 581 permanent openings divided into 133 for fish, 160 for game, 157 for conservation officers, and 31 for public relations technicians. In addition there is likely to be need for 223 temporary personnel.

Assuming that next year's crop of graduates will be distributed amongst the fish and wildlife agencies, military services, teaching or returning to school in the same percentages as this year, it is calculated that there will be approximately 500 seeking employment. Compared to the 581 possible job openings it is evident that the supply and demand are about in balance. This is not to imply that every graduating fish and wildlife student will find a job this coming year. The outlook is very favorable, however, particularly when the needs for conservation officers and public relations men are added to the numbers for fish and wildlife technicians.

The employing agencies indicate a decided preference for experienced men but with a master's degree. The trend in college enrollment points to an increased number of students going into graduate schools. A question, posed to the administrators by the Professional Standards Committee as a part of the questionnaire, dealt with shortcomings in the present technical men. Oddly enough, none complained about any weaknesses in the technical wildlife and fish courses but there was decided agreement that the technicians needed more education in basic courses. English, writing, public speaking, soils and land management are some of the subjects suggested. Obviously, the student cannot squeeze in a full schedule of specialized courses and get the broad basic education in a four-year period. The employers want men with a master's degree and apparently the students are aware of the value of the extra period in school.

The administrators quite naturally desire experience as one of the qualifications and unanimously favored summer experience for students. The problem is how to make this possible. The Committee suggests that each administrator should consider the possibilities of adopting a program of summer employment for students. The first year or second year students might not have any more responsibilities than

those of a common laborer at the game farm or fish hatchery. Advanced students might be used as labor foremen, refuge manager assistants, or crew members on investigation and survey teams. This will give the students valuable experience, weed out the ones that planned on a life of hunting and fishing, provide the basis for in-service training and indoctrination in agency policies and give an opportunity to watch candidates for permanent employment when their schooling is finished. The idea is not new and several agencies are now following this program.

From the analyses of the comments of the teachers on the one hand and the administrators on the other, the Committee strongly urges that the two get together on the common ground of turning out a satisfactory product—the graduate with adequate training. By clarifying what the administrators want the teachers can revamp their training program. At the same time the instructors will come to appreciate the manifold problems of the average administrator besides the supposedly major one of managing the fish and wildlife resources.

Another point that has received considerable concern is the number of schools teaching fish and wildlife courses. The Committee sent questionnaires to 63 colleges and may have overlooked several more. Nearly every State has at least one institution giving biology, fish or wildlife training. It may not fall within the province of this Committee to pursue this matter; however, thought should be given to the advisability of having fewer schools with higher training standards.

Some of the teachers expressed concern over the residence requirement for employment in the State fish and game departments. This is a natural condition, particularly at times when there is an abundance of qualified men living in a State. Yet 26 of the States indicated they hired, or their examinations were open to non-residents. Another 17 qualified their answers to the question by statements such as, "if no suitable residents were available." The Committee did not solicit information on the number of non-residents employed by the various States and Provinces. However, for the long range value to the profession and the possible benefits to the individual agencies the Society should actively campaign for wider adoption of this principle.

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REPORT OF THE COMMITTEE ON RESEARCH NEEDS

In discussing research needs in the field of wildlife some definitions are essential and certain limitations must be established. There is a great deal of vagueness, of overlapping in concept, as to what research is, how it can be subdivided, and what its objectives may be.

Fundamentally, research is an objective, organized, studious inquiry aimed at the discovery or refinement of facts and methods or their verification. Its first generation of offspring include

management procedures, and the later descendants are tangible benefits to the public. The car in which it rides is theory (logical thought projected beyond immediate verification), the fuel is ideas, and the motor is money.

The objectives of research are twofold.

In the abstract research usually originates with the research worker and is aimed at satisfying an inherent curiosity on the part of the investigator in a field in which he has an especial interest and at least a modicum of competence. This type of research activity does not envision practical application, but it may produce practical information of great value. Much of the research on territoriality in passerine birds has been of this nature. Practically all work on the factors initiating bird migration has been done to satisfy an age-old curiosity and not for the benefit of flyway biologists. The other objective is of a practical nature, and its aim is almost entirely at prediction. If a condition exists now, will it change, and if so in what direction? If a measure is undertaken or an act done what will be the result in the future? As a corollary of this, and of practical value, what is the relationship which exists between causes and effects, whether the cause is man-induced or a natural phenomenon?

Less comprehensive research endeavor is initiated in many ways, commonly from external sources. The sportsman has a problem. It is stated to the administrator, the administrator requests the answer from his research group, and, if not available, the answer is "discovered" through research. Such research may be shallow, restricted in utility, and subject to variation. Such research is, as often as not, the producer of facts of limited geographical significance. The discoveries from such research may be applicable at the time, but not in five years. But is has the advantage of producing an answer in a short time, an answer for which there may be immediate need when time is an important factor.

Research is qualitatively different from management in a very fundamental aspect. Management can plan a specific program and follow it to completion according to the previously developed outline. It can set about to plant a certain number of shrubs, to establish a certain acreage of marsh, to follow a certain stocking procedure, and at the end of a given period it can show that it has done its job. But because of the inherent nature of research, it may have to travel unknown, unpredictable paths. On the basis of chance alone it can reach a desired goal 50% of the time and it can miss it with equal facility. It produces negative results as well as positive. Such negative results may be of value in setting up limits, in telling what *not to do* as well as what *to do*. Negative results do give us a better understanding, and in this they have value. Management can reach its goal, a positive one, nearly all of the time. This fundamental difference must be understood by all with any interest in wildlife welfare.

These points stand out, then: Short time, superficial studies may be of limited value and at times may mislead, although they may be of importance locally and for the time. Research may give positive answers and also it may produce negative results of no immediate practical importance.

It is necessary first of all to distinguish as well as we can the differences which exist between management and research.

Certain fields are far ahead of the wildlife field in this respect. Forestry, for example, considers inventory of growing stocks, determination of growth rates, classification of sites, and regulation of harvest as management activities. On the other hand, new or better methods of obtaining inventories, or of regulating harvest, are research activities. So are fundamental studies of the significances involved in all management activities.

Management is the taking of facts and methods, largely obtained through research efforts, and applying them to manipulate populations of wild animals where this manipulation is of practical significance.

The differences between these fields are subject to individual interpretation, and the time may never be reached when there will be a clear-cut division between the endeavors unless it is an arbitrary one. There will always be marginal cases where an activity might be thrown either way. And in these activities coordination and forbearance are essential.

An important reason for this is that there are different kinds of research.

It varies from elementary studies to fundamental, profound investigation; from direct censuses, elementary food habit studies, or hunter kill analyses, to studies of population dynamics, physiological responses, and total ecological interrelationships. It varies from studies completed in one season to others which may not be completed in a decade.

In this progression one sees increasing complexity and increasing importance in elucidating the fundamental laws upon which populations depend for their government. The more fundamental the research, upon which management is based, the more predictable will be the success of a management operation.

An anomaly exists at this point.

Even if we agree that fundamental studies lead to the best quality of research, we find that the fewest research workers are carrying on fundamental studies. There aren't many who are free to undertake them who at the same time are endowed with the curiosity, the initiative, the ingenuity, and the perseverance to follow them through. Too often a research worker gains prestige in a certain field and is immediately in demand for many kinds of services which reduce his research time. Then, if he is good enough, he is removed completely from the field and given other more remunerative tasks.

We also find that support for such studies is hard to obtain. As an example, the Federal Aid Policy Manual (revised 1951), which was approved through joint conference with the State and Federal Services, states in Section 1511:

> *Nature of Projects.*—Investigational projects must be confined to such fact finding on problems of fish and wildlife management as may be necessary to administer efficiently these resources. While almost any study might have a general bearing upon management practices, those undertaken in accordance with the laws concerned should be limited to research of an applied nature. Such projects should be confined to problems that are capable of being solved in a relatively short period of time. Academic studies aimed at procuring information that has no visible promise of early management application should be undertaken

by educational or other agencies without reference to the Federal programs.

Such a policy, if followed by many agencies that are in a position to support research, will go far toward the suppression of research which may be of greatest value. Conceivably it can dissipate investigational funds on the less efficient projects. It can effectually play a Delilah to a Samson, substituting a crew cut for long locks.

This Committee does not see the expediency of attempting to turn all wildlife research, or even the major part of it, into basic channels. But it does feel that no obstacles should be placed in the path of those scientists capable of carrying on fundamental studies. Nor does it isolate any one agency as being an impediment. Any research agency or any agency in a position to support research, which makes it difficult to carry on a balanced program, has the specific responsibility of seeing that its policies are corrected if they are too circumscribed.

There is a real danger that management, which of necessity gets the larger amount of all funds expended on the welfare of wildlife, will put *too much confidence* on research production which will not withstand the test of time, and that all wildlife endeavors will be subject to a searing scrutiny if a time is reached when the vast sums of money expended do not seem to have produced commensurate benefit. If and when such an event occurs, research will come in for its share of criticism, but efforts of a basic nature will have the cleanest shirt.

We wish to reiterate, therefore, that no impediment be placed before competent research planners and investigators; that those without sin cast the first political stones at the so called research visionaries.

Finally, we recommend that research be encouraged in the following fields, by all responsible agencies in a position to give such encouragement.

1. The actual, measurable value of habitat changes such as (1) upland plantings or (2) development of aquatic or semi-aquatic habitats. Wherein are these programs successful, where do they fail and why?
2. The effect of refuges on the whole or any part of the wildlife biota. Where do they succeed and what are their failings?
3. A broad evaluation of the environmental pressure factors. Can generalizations now be made on the effect of predation and disease? If not, then research, not on an area or state basis alone, but on a regional or nation-wide basis should be undertaken.
4. More studies on population dynamics. What are normal turnovers in game species? What are safe turnovers? How much can hunter harvest be substituted for natural losses in any given species?
5. More fundamental and coordinated studies on the effect of man on wildlife, from changes in agricultural practices through pollution of aquatic habitats to possible pollution of terrestrial habitats through injudicious use of various chemical agents.
6. The whole problem of control of undesired species, with emphasis on the substitution of natural,

ecological control for the common artificial methods now in use.

7. Studies on the economics of wildlife.

The above listing purposely has been couched in broad terms. There is plenty of room for refinement by intelligent use of imagination. Nor is it considered to be complete. But it does represent areas in which we need more information—not only now but yesterday.

This committee does not feel that it has jurisdiction, and possibly not the competence to state *how* this research should be done, but it is sure that it should be done, and it pleads that all states and all agencies involved encourage at least a minimum of basic study in which the time element is a minor one, and the demand for immediate application negligible.

We who are interested in the welfare of wildlife cannot debate the importance of short-term "practical" investigations, but we should encourage as much basic research as can be carried on—perhaps just a little more. We must also remember that brains are a commodity which must be paid for. Ten well paid, competent investigators will produce more then twenty of the quality purchasable for half the money.

In concluding, the committee makes the following points:

1. Research on a broad front, including all types from superficial to basic is essential to intelligent management.
2. No hindrances should be allowed to exist which will militate against any one of these research efforts. As examples, policies should not limit directly or indirectly the channeling of public funds to agencies, established for or capable of carrying on basic research, which do not now prosecute such studies or which are insufficiently supported. Nor should such policies be self restrictive upon research programs now being followed by recipient agencies.
3. If good research is to be done it must be properly supported, both in salaries and in operation.

Your committee recommends the approval of this report and its dissemination to the members of the Wildlife Society and to such persons and agencies designated by the Council.

Your committee considers this report as a preliminary one, to preface further studies which should be made on the subject under investigation. It feels that it would be helpful if (1) there could be developed a classification of types of research from fundamental to superficial, however arbitrary this might be, and (2) an examination could be made of at least sample research programs throughout the country in an attempt to fix present research balance and more specifically to discover what research programs could benefit by modification.

Therefore your committee recommends that the President reappoint a Research Needs Committee for one more year.

Respectfully submitted,

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PROFESSIONAL STANDARDS AND TRAINING IN THE WILDLIFE FIELD

REPORT OF THE COMMITTEE ON PROFESSIONAL STANDARDS

The need for improving the standards of the wildlife profession in the fields of wildlife training, research, management and administration is generally recognized. How to accomplish this improvement, how to render the Wildlife Society of more benefit to its members, or how merely to take a few firm steps in this direction, were some of the problems considered by the Committee on Professional Standards.

One of our predecessor committees on wildlife professional standards had similar problems in mind when they (Leopold et al. 1939) wrote "Academic and Professional Training in Wildlife Work." This excellent report outlined criteria by means of which a wildlife student's professional standards and attainments could be measured. It also indicated some of the equipment and facilities needed in schools offering professional wildlife training. English (1942), Hendrickson et al. (1945), Bennitt (1946) and Turner (1948) made further contributions to the literature dealing with professional standards, training and opportunities in the wildlife field.

Have wildlife schools improved in recent years? Do present day wildlife graduates score higher on the criteria of professional preparedness proposed by the 1939 Committee than graduates of yesteryear? Should wildlife schools be accredited in a manner similar to forest school accreditation methods? Is the quality of employees in wildlife agencies improving? Should a code of ethics be adopted by the Wildlife Society?

Our committee joined forces with the Committee on Employment to get the reaction of conservation workers throughout the country to some of these problems. Questionnaires prepared jointly by the two committees were sent to 63 colleges in the United States, Alaska and Canada and to the State and Provincial Fish and Game Departments and certain Federal agencies concerned with wildlife management. Replies were received from all of the State departments except Kansas, from 4 Canadian Provinces, from all of the Federal agencies contacted and from 52 of the colleges and universities to which questionnaires were mailed. We appreciate the excellent cooperation received from these agencies and institutions and wish to thank them one and all for their assistance.

During the course of the Committee's work our attention was called to the book "Forest Education" by Henry S. Graves and Cedric H. Guise (1932). We were much impressed by the similarity of problems confronting foresters and forest educators 20 years ago with the problems we now face. In the preface to their book the authors stated;

> During the past thirty years the number of collegiate institutions offering instruction in forestry has multiplied until there are now listed twenty-six in the United States and four in Canada. There has been a general feeling among foresters and others that there are more forest schools of the higher grade than are necessary or justified, that there is a wide diversity of educational standards and performance

among them, and that there are many weaknesses in the training of foresters for the various occupations and for creative work involved in the development of forestry on a broader scale.

This statement requires but little revision to be applicable to our field today.

NUMBER OF FISH AND WILDLIFE SCHOOLS

Because of the widely divergent opinions as to what constitutes wildlife training, it is difficult to state, with exactness, the total number of fish and wildlife schools. There are at least 50 institutions however, which now offer some training in wildlife management as compared with 37 schools listed by Swanson and Yeager (1947) a few years ago. In the much larger (employment-wise) field of forestry, professional education in the United States is offered by 34 colleges and universities of which only 25 are accredited by the Council of the Society of American Foresters (Clepper, 1951). Twenty-five additional schools offer introductory and specialized courses in forestry on a non-professional basis. (Journal of Forestry 49(9):672).

We believe that because of the increasing numbers of schools offering conservation courses it is becoming increasingly important for students and wildlife employers alike to make a distinction between those institutions well prepared to offer professional training and those poorly prepared. Many schools, offering only introductory courses in conservation, render a distinct service in providing vocational agriculture, liberal arts and college of education students with some idea of natural resource uses and management.

Our survey indicated that in-service training was becoming more popular and that some administrators preferred to employ BS graduates with broad, basic training and train them according to their special needs rather than employ men with more advanced training. This was especially true for management positions. Generally speaking, however, the administrators preferred men with the Masters degree and at least one year of experience.

NUMBER OF FISH AND WILDLIFE GRADUATES

Although the number of students enrolled in wildlife training institutions has decreased for two successive years there is a current surplus of graduates with some decrease in the percentage of them obtaining employment in the wildlife field. During the school year 1950-1951 a total of 495 wildlife students graduated from 40 colleges and universities as compared with 633 the previous year. The ratio of B.S. graduates to post graduates has decreased from 4.6:1 in 1949 to 2.6:1 in 1951. Competition for jobs, the G.I. Bill and the realization on the part of employers that advanced training is desirable for certain types of wildlife positions have probably accounted for this trend.

A surplus of college-trained workers is not altogether a waste of manpower. Due to a large number of men available for employment, wildlife employers have an opportunity to carefully screen and select the candidates with the best qualifications. Competition for jobs has resulted in a broadened base of employment with more wildlife biologists going into conservation officer positions,

private posts and related fields. It has resulted also, in a greater segment of the population with an active interest in conservation programs and wildlife legislation. A surplus of graduates is not confined to wildlife majors or to graduates in this country. In England, for example, "The total estimated demands for professional biologists in the period 1950-1954 total 2,493 as compared with an estimated output of 3,434 graduates over the same period." (Editorial in the March, 1951 issue of NATURE, 167(4245): 371–372).

The total number of people who have obtained wildlife training in college since the early 1930's is not known. Our records indicate that since the establishment of Cooperative Wildlife Research Units in 17 widely distributed colleges and universities, 1519 wildlife students have graduated from these institutions including 1127 with the bachelor degree, 352 with the master's degree and 40 with the Ph.D. degree. During each of the past 3 years, wildlife graduates of these Unit Schools constituted approximately 50 per cent of the total known graduates. Assuming that this ratio has been about the same since 1935 we arrive at a figure of approximately 3000 degrees awarded to men who received college wildlife training. Allowing for duplication of the men who received advanced degrees, the total is reduced to approximately 2225 of which considerably more than one third graduated during the past two years. Even so the number of wildlife graduates is small compared with forest school graduates of whom there were 2005 in 1951 alone (Clepper, 1951).

A total of 948 employees were reported to the Committee by 40 state fish and game administrators as having had wildlife training in college. If this rate of employment applies to the remaining 8 states we get a total of 1138 college trained wildlife men in the 48 states. Provincial and Federal agencies reported 492 additional employees having wildlife training. This brings the total to 1630 college trained wildlife biologists currently employed in the wildlife field excluding wildlife professors. Although this figure undoubtedly is too low it indicates how rapidly the supply and demand situation is changing with regard to wildlife graduates. It also indicates a rapid turn-over in trained personnel.

CRITICISM OF CURRENT WILDLIFE GRADUATES

Fish and game administrators gave some very interesting replies to the question, "In your opinion what are the most common shortcomings in current wildlife graduates?" There answers, abbreviated and grouped below, should provide valuable information for wildlife instructors and students.

No. replying	*Shortcomings of graduates*
16	Inability to express themselves effectively and accurately in English.
15	Lack of sufficient experience and ability in applying management and research techniques.
13	Inadequacy in social and public relations and in personnel management.
12	Poor attitudes; poor work habits.
10	Insufficient grounding in basic scientific courses; too much specialization with resultant lack of interest and knowledge of other wildlife problems.

Other shortcomings mentioned, included lack of basic knowledge of land use, insufficient experience in operating field equipment, lack of appreciation for law enforcement as a part of management and inadequate knowledge of work being carried on by the various federal, state and private conservation agencies.

Another criticism that might very well have been directed at wildlife students is the small percentage of them that are members of the Wildlife Society. Thirty-four colleges and universities reported having 365 graduate wildlife students of whom 135 (37%) were members of the Society. At a cost of $5.00 per year, it would appear that a larger percentage of these students, who expect to make wildlife work their life profession, would be members of the Society if for no other immediate reason than to get the JOURNAL OF WILDLIFE MANAGEMENT. As would be expected, an even smaller percentage (18%) of the senior wildlife students, were reported as being members of the Society. Many of these trained men, even after getting wildlife jobs, do not exhibit sufficient interest and professional pride to become members. Is this a reflection on these men alone, or is it also evidence that the Society should be rendering greater service to the profession?

In answer to the question, "What should these wildlife students get in their training that they are not getting?", replies of the administrators were as follows:

No. of replies	*Suggestions for improving training*
38	More training in basic courses such as mathematics, chemistry, statistics, physics, biology, ecology, soil science, meterology, animal nutrition, physiology and English with the latter, in the sense of journalism and report writing, being mentioned more than any other subject.
36	Other courses specified as being important to include in the curriculum of wildlife students were public speaking (mentioned by 8 administrators), psychology (6), principles of land use (5), surveying and mapping (3), engineering and maintenance of equipment (3), political science (2), rural sociology (2), personnel management (2), business management (2), bookkeeping (1), law (1), and government (1).
19	More attention to public relations
8	More actual experience in the field with competent technicians and administrators before graduation.[1]
5	More attention to law enforcement.
3	Better knowledge of administration.
1	Training in "roughing it."
1	Undergraduates should be required to select and complete a minor wildlife research project before graduating.
1	Students should be imbued with the necessity of conserving basic resources.

[1] In answering a separate question, "Are you in favor of requiring wildlife students, before they graduate, to obtain employment during the summer or on a part time basis with some conservation agency for experience?" 57 administrators replied in the affirmative, 6 in the negative while 1 was undecided.

In analyzing these and other comments compiled by the Committee on Employment it is obvious that administrators place a great deal of stress on

the ability of an employee to express himself clearly and effectively in English and to get along well with people. Although the administrators indicated that many wildlife graduates were unable to apply, with accuracy and confidence, wildlife techniques in the field, the most common criticism was that they lacked sufficient training in basic courses.

Due to the steadily increasing information pertaining to special wildlife techniques, instructors are finding it difficult to cover the ground they consider desirable in the various wildlife subjects. There is a tendency to add new courses of a technical nature and to decrease the time allotted to fundamental work. Again we find a parallel with the forest schools of 20 years ago. At that time Graves and Guise (1932—page 21) stated:

> The forest schools are subject to pressure from two standpoints: first, to increase their standards in general education and technical training, and second, to make their work more practical in order that the graduates may sooner and more effectively adapt themselves to the realities of applied forestry. These two demands are not necessarily in conflict, and it is possible to reconcile theory and practice in a way greatly to strengthen both. Nevertheless, there is considerable confusion of thought on the subject of practical training, arising in part from the fact that there are many subordinate activities in forestry that may be performed by men with only a restricted formal training in forestry or with such training as may be obtained through apprenticeship.

Most of the shortcomings of wildlife graduates listed by fish and game administrators are not unique to wildlife personnel. An individual's inherent capabilities, his interests and personality have as much to do with one's success in wildlife management as in other fields. Also it should be emphasized that colleges cannot be expected to complete a student's training so that on-the-job learning or a period of apprenticeship is unnecessary.

SHOULD WILDLIFE SCHOOLS BE ACCREDITED?

Admittedly there is much confusion as to what constitutes adequate training in the wildlife field. There is much diversity in the faculty and facilities at the 50-odd institutions offering wildlife training. Wildlife employers are prone to expect too much of a college graduate who has had only four years of training and little or no practical experience in the field. They are likely to expect a man who has had a few wildlife courses to be capable of performing research requiring much skill and vision or to be capable of administering difficult land development projects simply because he is a college graduate. Some are apt to pay too little attention to the adequacy of training at different institutions, accepting graduates of a poorly equipped or poorly staffed school as readily and with as much confidence as graduates of a superior school. Also, regardless of the school, due to the rapidity with which the wildlife field has grown in recent years, wildlife graduates of all grades, good and poor, have been employed. Some have been misfits.

The college graduate often has an exaggerated opinion of his importance and abilities. He tends to underestimate the know-how of his scholastically untrained associates whether they are his supervisors or whether they hold lesser jobs. When he realizes that he is not

able to accomplish what is expected of him both he and his employer are likely to criticize the training institution for not teaching the right things.

Will accrediting the training institutions in a manner similar to forest school accreditation solve these problems and relieve the confusion? Of 40 wildlife professors expressing an opinion as to the feasibility of accrediting wildlife schools, 17 favored accrediting, 13 opposed accrediting and 10 were undecided or skeptical as to how and when wildlife schools should be accredited. Of 59 Federal, State and Provincial game and fish administrators answering this question, 47 favored accreditation, 9 opposed it and 3 were undecided.

Few suggestions were made by either the wildlife professors or the administrators as to how they thought accrediting should be accomplished. To get some information regarding methods of accrediting the Committee contacted Dr. R. G. Gustavson, President of the National Commission on Accrediting; Mr. Henry Clepper, Executive Secretary, Society of American Foresters; and Professor Myron Krueger, Chairman of the Committee on Accrediting for the Society of American Foresters.

Excerpts from Dr. Gustavson's letter of November 26, 1951 are quoted here:

> The National Commission on Accrediting is an organization which was brought into being at the request of the colleges and universities of the United States. Accrediting agencies have multiplied very rapidly during the past twenty-five years and have now become a threat to the integrity and freedom of the institutions themselves. It is for this reason that the National Commission on Accrediting is working very hard to try to find ways and means of insuring students that the schools they attend will give work that is adequate for the profession they are training for and at the same time that the profession will be protected from incompetent people. This is a very difficult task. We are convinced, however, that accrediting agencies are not the means to this end.
>
> I would suggest that you have some sort of committee on Standards and that you attempt to cooperate with the various institutions that are giving courses in your field with respect to the standards and the quality of work which they do. In other words, a cooperative plan is one that is highly desirable, one that involves cooperation for professional development, and accrediting agencies of the type which we now have would not be desirable. In fact, I can assure you that the National Commission on Accrediting is doing everything within its power to simplify this process and not to complicate it further.

Although the National Commission on Accrediting recognizes that accrediting agencies have often been instruments for the maintenance of high educational standards, have protected society against inadequately prepared professional practitioners, have been helpful to students and parents seeking to identify sound institutions and have aided institutions in withstanding improper political or other non-educational pressures, it feels that the greatest strength of the institutions can be developed through freedom to experiment in the ways and means of education and to exercise both responsibility and authority in administering their programs.

Grading sheets, bases for accrediting schools of forestry and notes on analysis of questionnaires were kindly provided our Committee by the foresters. Their plan is based upon 15 years of study and experience with accrediting and, should the Wildlife Society choose to attempt wildlife school accreditation, the infor-

mation would be of great value. "The Forest Education Inquiry" conducted by the Society of American Foresters and made possible by a grant of $30,000 from the Carnegie Corporation of New York, provided the information on which forestry school accrediting was based. No attempt will be made to describe the system here as the plan is complicated and literature regarding it is readily available.

After careful consideration of the information at hand—immaturity of our profession, resistance of college and university authorities to further accrediting, costs of accrediting and other problems, the Committee would like to suggest that the Society attempt no accreditation at this time. We believe that it would be possible and highly desirable to work with the National Commission on Accrediting to bring about a better understanding between wildlife employers, wildlife instructors and wildlife students without formal accrediting of the training institutions. As a step in this direction we suggest that a committee composed of wildlife administrators and college professors review the various research, administrative and operational phases of the wildlife field, determine the qualifications and types of personnel needed to handle the respective jobs and recommend revision of the training as necessary. Concise but clearly written job descriptions for conservation officers, law enforcement personnel, game managers, fish managers, biologists, Federal Aid coordinators etc., if provided the wildlife training institutions, would be of much value to students and instructors in developing wildlife curricula. It seems obvious that the extent and type of training desirable for students who expect to do basic research or college wildlife teaching should differ from the training needed for many management or conservation officer positions. That advanced training is deemed desirable for teaching, is reflected in the fact that 52 per cent of last year's Ph.D. graduates obtained teaching positions as compared with 2 per cent of the bachelor degree men and 6.5 per cent of the masters degree men.

We recommend further that this committee or another committee on Professional Wildlife Training, prepare a report on "Bases for Evaluating Professional Training in the Wildlife Field." This could be patterned upon the foresters' bases which have been developed over a period of nearly 20 years. The report could then be used by the schools to evaluate their own training facilities.

Thirdly, we believe that many of the shortcomings listed by fish and game administrators in our questionnaires really were not shortcomings of the training institutions but of many of the men who seek to get into wildlife work through taking college training in this field. Screening of wildlife students is necessary. Although size of enrollment is important to colleges and universities, because of the financial support that can be secured, and there is often a temptation to recruit for the sake of numbers, we recommend that prospective students, who appear to be incompetent or show poor aptitude for wildlife work, be discouraged. Actually we believe that schools are judged, to a large extent, by the success of the graduates. A school graduating a relatively few well qualified students may enjoy

a better reputation than schools turning our larger numbers of poorly trained men.

A fourth step would be to encourage the employment of upper classmen or graduate students for summer or part time work. This would give wildlife employers an opportunity to appraise prospective candidates for full time jobs after the students graduate. It would also provide the students with needed practical experience and help eliminate the misfits in the field.

A fifth step would be to encourage employers to ask wildlife schools for recommendations and reference letters pertaining to job applicants; and to take the time to spell out, in considerable detail, the positions to be filled, duties of the workers, amount of public relations involved, and type of management or research contemplated, so that the student's advisor can exercise good judgment in indicating whether the applicant is likely to succeed. The wildlife instructor, of course, should give a fair and unbiased evaluation of the applicant.

One well known game administrator with many years of experience suggested that arrangements might be made whereby wildlife teachers, on a basis similar to a short-term sabbatical leave, could change places with practitioners. This would result in both the practitioners and professors gaining worthwhile experience, the former in teaching and the latter in practical field problems. Another administrator pointed out that he had noticed great improvement in the students he employed after having discussed his needs with wildlife instructors.

The Society might also work towards improving inter-state employment. Although most (43) State conservation departments are permitted by law to employ non-residents to fill technical positions, relatively few hire any significant number because of political pressures or precedent to employ residents only. Admitting that residents are more familiar with local conditions than non-residents, we believe that the standards of employees could be raised materially by dropping the barriers against non-residents.

As an aid to schools in the self-evaluation of their training methods it has been suggested that employing agencies might provide wildlife schools with figures showing the percentage of graduating students who pass certain Federal and State Civil Service examinations. Precedence for this is found in the U.S. Forest Service which rates the schools of forestry according to the percentage of successful Civil Service examinees. Considerable care should be taken in using such success ratios lest training be consciously pointed towards the type of questions asked in the examinations and not kept sufficiently broad.

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OBITUARY

HERBERT LAWRENCE DOZIER

1894–1951

Dr. Herbert Lawrence Dozier was born on June 24, 1895, at Wilmington, North Carolina. He died December 4, 1951, after more than 18 years of outstanding service with the Bureau of Entomology and the Biological Survey and its successor, the United States Fish and Wildlife Service.

Dr. Dozier's college work began at the University of South Carolina, Columbia, where he obtained the degree of Bachelor of Science in Agriculture in 1915. It continued at the University of Florida, Gainesville, where he was awarded the degree of Master of Science in 1917. Dr. Dozier attended the Universite de Cleremonte, Ferrand, France for one year (1919) after World War I. At Ohio State University he was a research fellow from 1919 to 1920, and he completed his work for the degree of Doctor of Philosophy at this institution in 1922. Dr. Dozier served one and one-half years as private first class, in the American Expeditionary Force in France during World War I. He held membership in the Association of Economic Entomologists, American Society of Mammalogists, and the Wildlife Society.

He began his Government career on June 15, 1915, as a field assistant in the Bureau of Entomology, and in June 1920, was appointed as Entomologist in Charge of their New Orleans Station. In 1923 he served as Chief Entomologist, Insular Experiment Station, Puerto Rico. He became head of the Department of Entomology, Ecole Central, Port-au-Prince, Haiti in 1925.

In 1935 he returned to the Bureau of Entomology and Plant Quarantine as associate entomologist at Mayaguez, Puerto Rico. Dr. Dozier enjoyed a wide reputation as a systematic entomologist, an interest which he followed as an avocation. He was the author of numerous papers describing insects new to science.

Dr. Dozier joined the Fish and Wildlife Service (then Biological Survey), as Director of the Fur Animal Field Station, Blackwater Refuge, Cambridge, Maryland, on June 13, 1937. His enthusiasm, energy, and ability to carry on research in the field of fur animal production were amazing. His efforts helped build support for Service activities, and Dr. Dozier became recognized as an authority and capable adviser on fur animal production projects related to the ecology and management of marshes. He played an important role in the development of wildlife habitat on State, Federal, and privately-owned lands. He had a profound interest in vegetation changes caused by hurricanes, storms of unusual violence, and prolonged droughts, and he showed the relationship of such factors to fluctuations in muskrat populations. He also conducted research on raccoons, especially their relation to the salt marsh habitat. His most recent challenge was nutria production in Louisiana and Texas, and in the effects this exotic might have on marsh management and the native fur animals. Some of Dr. Dozier's outstanding contributions concerned the development of means for estimating muskrat numbers, maintaining a balanced population, and improving the habitat. He did notable work on methods of handling the muskrat crop, and on salinity as a factor in production. He was also a student of photography, carrying his studies expertly from the composition of the picture and its exposure to the finished enlargement which was a work of art.

During his years in Government, Dr. Dozier published many scientific papers and wrote numerous government publications on subjects pertaining to entomology, ecology, and fur animal production. He was the author of more than 100 scientific articles and bulletins. His latest contribution "Muskrat Production and Management", a Fish and Wildlife Circular, is in process of publication. His death left a gap in this line of research that it will take many years to fill.

Dr. Dozier's interest in and knowledge of insects, plants, and animals, was outstanding. He was not just another member of the "green thumb" gentry, but a distinguished plant breeder of national reputation. He is well known for having produced the most unusual colors

and combinations of colors in dahlias, iris, and daisies of his own breeding.

In showing Dahlias, Dr. Dozier won the Governor O'Connor silver trophy in Baltimore, twelve American Home Magazine achievement gold medals for best seedling in show, the most coveted award, two Michell gold medals for achievement in horticulture, one Home Beautiful Magazine gold medal, one American Dahlia Society gold medal, one Delaware Dahlia Society silver and two bronze medals, two Max Schling gold medals and many ribbon awards. In 1951 he developed a new iris seedling of the tall bearded variety, which he named "Lady Dozier". It was awarded honorable mention.

Besides his wife, he is survived by two sons, two daughters, mother, three grandsons, two granddaughters, a brother and a sister.

Herbert Dozier not only enlarged his official world of Science but through his inspired creative ability, brought new beauties to give us spiritual satisfaction and uplift in a troubled world. His contagious enthusiasm on the job and the tremendous vitality and zeal with which he pursued his many interests were a constant inspiration to his associates. He was indeed a true friend who will be sorely missed by all those who knew and loved him.

FRANK G. ASHBROOK

REVIEWS

Range Management—Principles and Practices. Arthur W. Sampson. New York, John Wiley and Sons, Inc. xiv+570 pp., 38 tables, 111 figures, 3 charts, 2 color plates. 1952. $7.50.

The author's work on the western range began with the Forest Service in 1908. In 1912 he became Director of the Great Basin Experiment Station in Utah, the first range experiment station established by the Forest Service. Since 1923 he has been Professor of Range Management at the University of California at Berkeley. In addition to many articles and bulletins, Dr. Sampson has published three earlier books in this field—"Range and Pasture Management", 1923; "Native American Forage Plants", 1924; and "Livestock Husbandry on Range and Pasture", 1928. These and associated contributions firmly establish the author as a pioneer and world authority in the field of range management.

"Range Management—Principles and Practices" consists of twenty-four chapters, arranged in four parts. Parts 1, 2, and 4 each consist of about 100 pages, Part 3, approximately 200 pages.

Part 1, "Range Management in Perspective", shows the relationship of range management with other fields of knowledge, considers the application of physiology and ecology, and includes a chapter on the history of grazing in the United States. A chapter on "The World's Grazing Practices and Problems" provides a basis for judging the relative importance of grazing in the United States.

Part 2, "Native Range Forage Plants", is concerned mostly with information on the description, location, and forage value of the more important range plants. Eighty-five grasses, four grasslike plants, and forty-five genera of forbs and browse are treated. Much of the material in this part appears to be a condensation of sections of "Native American Forage Plants".

Part 3, "Improvement and Management of Range and Stock", is the most useful of the four parts of this book. It considers reseeding techniques, management practices relating to water and other factors, forage utilization, range surveys, and husbandry and management of livestock on the range. A section of one chapter treats with the size and importance of the rapidly developing livestock grazing in the Southeastern States.

Part 4, "Protection of Land Resources and Range Livestock", includes information on damage of livestock to timber reproduction, management in relation to poisonous plants, foraging and predatory wildlife, and soil erosion. The final chapter of Part 4 is concerned with administration of public grazing lands and gives a good, impartial discussion of the organization and work of the several Federal

agencies having responsibility in this field.

The author states that the book has been a long time in making. Because of this the many citations given at the end of each chapter usually include the more important references. In some chapters, notably in Part 3, references as recent as 1951 are given, and in these cases the material is noticeably up-to-date. In other chapters of the book, however, there appears to be a neglect of current information. For example, in Part 1 the tabulated data on number of livestock are for 1940 and the big game population estimates are for 1941.

Wildlife workers will agree with Dr. Sampson that more work needs to be done on browse. Moreover, information in the book strengthens such a viewpoint. In the discussion of range inventory eighteen forage types are described; nine of these are shrub in character, and five others have shrubs as important components. Perhaps this situation indicates that big game technicians and others should undertake a substantial work in book form on the single subject of shrub management.

Wildlife is covered briefly, and when discussed is too often viewed in the light of something that conflicts with livestock grazing. This implication is certainly contained in the title of the only chapter on wildlife, namely "Foraging and Predatory Wildlife on the Range", and in its inclusion in Part 4, "Protection of Land Resources and Range Livestock".

Despite the shortcomings from the viewpoint of wildlife management, "Range Management—Principles and Practices" is at the same time a most valuable contribution to workers in the field of wildlife management. In general, the principles and practices are applicable to big game management and in many respects to other forms of wildlife. Part 3, "Improvement and Management of Range and Stock", is especially helpful since it gives information that the wildlife manager can use in reseeding, cover manipulation, condition and trend, forage utilization, and inventories. In addition, the book gives in a condensed form data on nearly all aspects of range management; information that any technician concerned with fish and game should have in order to understand the scope and problems of range management and the range industry. The author's repeated reference to damage from overuse, and insistence that range should be moderately used, cannot escape even the most casual reader.—LLOYD W. SWIFT.

Range Management, Principles and Practices. A. W. Sampson. New York, John Wiley and Sons, Inc. xiv+570 pp. 2 colored plates, 111 figs., 38 tables, several charts. 1952. $7.50.

This review of Dr. Sampson's recently published volume pertains only to that portion dealing specifically with wildlife. The major portion of the text no doubt will be reviewed by someone more competent to discuss these other important and far-reaching aspects.

It would appear that Dr. Sampson has encountered some difficulties in trying to condense into small space, subject matter which even he handled on a broader basis in his earlier volume, "Livestock Husbandry on Range and Pasture" (1928). In his former discussion of "Animals that Prey upon Livestock and Rodents that Destroy Forage Crops," and related subject matter, Dr. Sampson devoted more than 50 pages of the text. In the current volume, he endeavors to cover somewhat the same ground in 24 pages. This has led to placing information in tabular form, which, though complete, is seldom as effective as written text which would permit elaboration or qualification as the case may be.

Aside from the information conveyed in tables, the coyote, referred to as "the diplomat of the range" is afforded only one-third of a page in the current volume. This unfortunately has led to the "cutting of corners" and the story is far from complete. There have been some oversights in the rapidly expanding literature on wildlife ecology and economics. One of the most unfortunate omissions has been mention of Sperry's comprehensive monograph on the food of the coyote (1941), in the preparation of which more than 14,000 stomachs were opened and the food in more than 8,200 was critically analyzed. Sampson has listed tabularly the foods of the coyote as "large game, lambs, calves, rodents, rabbits," etc., when, as a matter of fact, the principal items as determined by Sperry, are (in the order of their volume) rabbits, carrion, rodents, domestic stock and big game. Such listing of the sequence of important food items can readily convey an erroneous impression.

No doubt mention of the grey or timber wolf as occurring sparingly in "parts of the cooler stretches of the Gulf States," is based on a confusion of *Canis lupus* with *Canis niger*, the red wolf.

In discussing field rodent control, some unfortunate statements have crept into the text, as for instance the following: "The principal poisons used are strychnine for prairie dogs, ground squirrels, jack rabbits, and pocket gophers; and red squill, barium sulfate and zinc phosphate for meadow and field mice." Whereas the first part of this statement is correct, the latter half is wholly incorrect. Red squill has never been used operationally against field rodents. Neither has barium sulphate nor zinc phosphate, although barium *carbonate* has been used in the control of commensal rats and zinc *phosphide* does have extensive use in the control of field mice.

The chapter on "Foraging and Predatory Wildlife of the Range" could have been helped by a critical preview by someone thoroughly conversant with current information on the control of troublesome wildlife. The single figure depicting 6 species of rodents and the jack rabbits is not on a par with the plant illustrations elsewhere in the text. Despite these and some other lapses of less importance, Dr. Sampson's approach to the problem of wildlife on the range is essentially sound. He believes in correcting the outstanding conflicts when and where they occur. He also recognizes that both predators and rodents are not always bad, and in some cases may be a definite aid to the range.—E. R. KALMBACH.

Introduced Mammals of New Zealand. By K. A. Wodzicki, Dept. Scientific and Industrial Research, Wellington, New Zealand. 255 pp. illus. 1950. $1.80.

The long isolation and the peculiar conditions prevailing in New Zealand have produced a remarkable and unique fauna. With the advent of the white settlers, deliberate attempts were made to acclimatize many new animal forms. Dr. Wodzicki deals with 29 species of introduced mammals which have been able to establish themselves in a wild state. The history of these introductions is succinctly described. The liberations, early spread and present distribution, the economic importance and control measures are described for the more "successful" introductions.

The author divides the appreciable changes in the New Zealand fauna, induced by man, into four parts. The first began with the Maories in the fourteenth century. With the visits of Captain Cook in the latter part of the sixteenth century, a definite introduction of exotics commenced. The intentional liberations (goats and pigs) during this period were presumably designed for food of the early settlers. The pioneers who organized settlements in New Zealand found only birds and fish on which to feed, thus a potential wild food source was the concern of these early settlers. The middle of the past century saw no end of introductions, always with the hope of a supplemental food supply for the increasing human population. Certain introduced species were eventually realized as pests. To combat the rabbit introductions, ferrets, stoats and weasels were released to minimize the leporid hordes. At this time the opossum (*Trichosurus*) introduced from Australia, was given rigid protection. Now it is an unmitigated nuisance, the destruction wrought far outweighing the profit obtained from the sale of skins. In the last period, beginning at the turn of the century, the area under settlement had reached the present pattern.

The purpose of the present survey was to collate available information on the biology, economics and the attendant problems which arose through these introductions. We learn that the squirrel and kangaroo could not adapt themselves to local conditions and have disappeared altogether. Favorable conditions have resulted in the widespread distribution of the rabbit and red deer, and these two species have become a serious economic problem. The latter has shown a considerable adaptation to changing conditions and has readily responded when liberated outside its natural range. While the red deer provides financial return through the sale of skins, the browsing effect has seriously altered the forests. The destruction of the vegetative cover has accelerated erosion, while direct damage to farming has occurred through food competition with domestic stock and through the eating of crops. The author believes that red deer are a serious menace in almost any part of their New Zealand habitat.

The white-tailed deer, introduced in 1901, has become well established and provides some sport. It has acted in some measure as a pioneer species in opening up the denser scrub and forest land for earlier liberated red deer, which would not penetrate the tangled growth until tunnels were formed by the bush dwelling and smaller white-tail. The black-tailed deer, liberated in two different habitats, did not become established.

The wapiti, successfully introduced in 1905, has become well established. It is believed that they interbred with the red deer. The effect on vegetation has not been determined and no valid conclusion can be drawn until a proper ecological investigation is made. A start in this direction was made by Olaus Murie in 1948, who studied the introduced elk herds of New Zealand.

Dr. Wodzicki has drawn attention to the need for a more scientific approach to the control and management of these introductions. Those engaged in management studies will profit from reading this important volume.—W. J. HAMILTON, JR.

Survey of Marine Fisheries of North Carolina, by Harden F. Taylor and associates. Univ. of North Carolina Press, Chapel Hill. 555 pp. 1951. $10.00.

This volume is the result of a literature survey initiated by a committee under the chairmanship of Robert E. Coker and carried through to completion by the staff of the recently established Institute of Fisheries Research of the University of North Carolina, under the executive direction of Harden F. Taylor. The purpose of the survey was not the gaining of new knowledge by research but was rather the summarization of the written record dealing with the fisheries of North Carolina which will in turn serve as a point of departure for future studies.

A section of 76 pages with 26 figures gives the highlights of the hydrography of North Carolina marine waters. It includes a discussion of the geography, circulation and water temperature both offshore and in the sounds, as well as salinity, pollution, and productivity. Part two covered in 208 pages the biology of the menhaden, edible fin fishes, oysters and other mollusks, shrimps, blue crab, diamondback terrapin, and a discussion of seaweed resources and a survey of marine angling. The third part is a section of 252 pages including numerous tables on the economics of the fisheries of North Carolina considered in the light of the fisheries of the United States as a whole. The economic pattern of the United States fisheries from 1887 to 1940 is presented with some comparison with those of foreign countries. Many of the thought provoking general conclusions of Dr. Taylor will stimulate further discussion (see Science, 1952, vol. 115(2983): 251–253 and Publ. Inst. Marine Res., vol. 2(1): 182–83). The work is valuable for the fishery biologist working in the Carolina shore fisheries, and for economists and others interested in the industry.—EDWARD C. RANEY.

Freddy Fox Squirrel. By R. W. Eschmeyer. 49 pp. illus. 1952.

Billy Bass. By R. W. Eschmeyer. 47 pp. illus. 1951.

Tommy Trout. By R. W. Eschmeyer. 48 pp. illus. 1951.

All published by Fisherman Press, Inc., Oxford, Ohio. Paper covers, 50 cents each; cloth $1.50.

Dr. Eschmeyer and his publisher are to be congratulated upon this first-rate series of children's books on game and fish. My only qualification to express an opinion on juvenile literature is that my own three children, now aged nine to twelve, are all inveterate readers, and have for several years been among the prize patrons of any public library within reach. I can say with assurance that among the many children's books, certainly numbering in the thousands, which have paused briefly in our home, none dealing with the out-of-doors or nature has had such real educational value in teaching ecology and conservation effectively as this series.

But the teaching value is not obtrusive—the children devour the stories without knowing they are learning. Dr. Eschmeyer exhibits a real genius in a type of writing which few technically trained people would even have the temerity to tackle—but which reaches a tremendous and impressionable audience. More power to him!

The three titles already issued are to be fol-

lowed by several more. Manuscripts of the titles on game birds and mammals, with which Eschmeyer is less familiar personally, are being checked for technical accuracy by acknowledged authorities. Highly recommended for all small fry interested in wildlife.—G. A. SWANSON.

The Clever Coyote. By Stanley P. Young and H. H. T. Jackson. The Stackpole Co., Harrisburg, Pa., and Wildlife Management Institute, Washington, D. C. xv+411 pp., frontispiece (color), 80+28 figs. 1951. $6.50.

One important activity of the Wildlife Management Institute has been the publication of popular monographs on birds and mammals of economic importance in North America. Besides those on game species of several types there have been two on large predators—the wolf and puma books by Young and Goldman. Both are of major value for both scientific and lay readers in summarizing the wealth of scattered information on these mammals. A companion volume on the coyote, anticipated for several years, has now appeared.

The present work, like the two preceding, is of joint authorship. Part I, dealing with history, habits, economic status, and control was prepared by Stanley Young and Part II, the systematic account, is by Hartley Jackson. The terminal chapter, of 63 pages, is of "References and selected bibliography."

The portion dealing with taxonomy (pp. 227–341) is based on study of 4,505 specimens and recognizes 19 geographic races of the one species, *Canis latrans*. The coyote is strictly North American, distributed from El Salvador to the Arctic Coast of Alaska, and from the Pacific Coast to eastern Texas and eastern Ontario, as a native. In recent years coyotes have escaped or been released and become established in several eastern states beyond the original range. Individual and age variations compounded with those of geographic character make precise definition of subspecies and their geographic distribution difficult. Trends among the recognized forms are evident, with the eastern races large and dark, a paling of color and reduction in size to the west and north, a brightening of ochraceous toward the Pacific Coast, and reddish dark color and short rostrum in subspecies of Mexico and southward. The conventional accounts of individual subspecies are accompanied by photographs of selected skulls (size not indicated) and by rather poor pictures of the right upper tooth row for each race.

The subject matter of Part I is under six major headings: distribution; habits and (life) characteristics (including reproduction); parasites and diseases; economic status; and measures used in control. Historical data are considered to indicate original distribution only west of the Mississippi and from the prairies of western Canada to about Mexico City, and that the coyote later spread to the south, northeast, and northwest. There are 17 centers of record in eastern United States, 1927–48. Entry into Alaska began early in the 20th Century, and by 1930 the animal had reached the northern and western part; in 1942–46 nearly 2,500 were offered for bounties in the Territory.

The usual weight range is 18 to 30 pounds, with exceptional records of 42, 53-1/2, and 74-3/4 pounds. Of 99 coyotes tagged at dens in New Mexico and Wyoming (years not stated) 57 were recaptured at various distances up to 100 miles from the tagging site and in one case 9 years later. Embryo counts average 5 to 7, but numbers possibly are influenced by maternal nutrition as litters of 9 to 12 are not uncommon and the top record is of 19 pups. Dens are used 8 to 10 weeks, and may be concentrated about favorable food sources; in one instance 8 dens with 48 pups were found in 4 townships centered on a ranch with chickens and young pigs.

The food is predominantly of mammals, with small attention to birds, other animals, and fruit. The inroads of coyotes on small livestock—poultry to calves—and deer, make the animals the most important of our destructive carnivores. Sperry's findings in 8,263 stomachs are reprinted in detail and there are two large summaries of food seen in stomachs by coyote control personnel (1919–28). These are followed by remarks on the relation of coyotes to deer, antelope, quail, and other wild species, and a long series (18 pp.) of reports on destruction of livestock.

The final chapter of Part I discusses methods used in coyote control: the government hunter, trapping, den hunting, fencing, snaring, coursing with dogs, airplane hunting, the coyote-getter, and bounties.

Author Young has been long and intimately associated with the economic aspects of the coyote. He probably has had as wide contact with persons suffering livestock depredations and both public and private control personnel as anyone in the United States and he has had much first-hand experience in these matters. An adequate account of coyote economics should include the pros and cons of the coyote's status in various environments, a *full* account of *all* methods tried in control, the organization of control operations from federal to private levels, the sums expended, the numbers of coyotes taken by various means, and the numbers of other carnivores taken incidentally or accidentally; finally the merits and shortcoming of all these operations should be appraised. The book lacks much of this material. Some omissions may stem from restrictions by official policy that would affect an author in government service.

In the early 1930's there was a great "poison debate" over a ten-year program ardently sponsored by some Biological Survey personnel and certain livestock organizations as a means to rid the country, once and for all, of pestiferous carnivores and rodents. This proposition was just as vigorously opposed by many scientific students and laymen interested in conservation—and privately by some members of the Biological Survey. The present reviewer has a vivid memory of the controversy because he was caught in crossfire by the two opposing groups for maintaining that both sides were too extreme. No topic in the entire history of wildlife affairs in the United States has ever aroused so much heated argument, oral and written. The proceedings of one lively session on predator control were reported in the Journal of Mammalogy (11: 325–389, 1930), but the "selected literature" in the present book lists only the papers of two speakers favoring the program.

The coyote was a central figure in the discussion of predators and this is much more a part of the story of the coyote than many of the small details in the present book. Yet the "use of poison" is dismissed here by a one-page account (p. 213), although there is incidental mention of control by poison elsewhere (*e.g.*, pp. 166–167). Strychnine, thallium sulfate, and Compound 1080 all have been used but only the first of these is mentioned. Material from the careful paper by W. B. Robinson (Fish and Wildlife Service) on "Thallium and Compound 1080 impregnated stations in coyote control" (J. Wildl. Mgt. **12**: 279–295, 1948) would be appropriate here. Other papers by Robinson are in the literature cited but this one is omitted.

As indication of the size of control operations, the average take in recent years has been about 90,000 coyotes and 10,000 bears, wolves, mountain lions, lynx, and bobcats. A decade ago (1940–41) of 123,000 coyotes captured, the means employed were traps, 70%; denning, 15%; poison, 9%; other, 6%. By 1948–49 coyote getters were used more than traps in taking predators and the percentage use of poison had declined slightly. The funds for predator control, by all agencies, have exceeded two million dollars in some years. This volume was the place for a detailed, straight-forward discussion of the entire predator problem, because the coyote is far the major factor.

The book suffers from frequent diversions and intrusions that obscure the sequence. These often result from inclusion of extensive quotations, using both published and unpublished sources, not shorn of trivial matter or condensed—two essential functions of an author in behalf of his reader. As examples, the chapter on distribution is disjointed (pp. 21–28) by a tale of hunters and coyotes in Mexico eighty years ago; six quoted pages (pp. 37–42) of coyote occurrence in Canada could have been briefed; and the account of coyote food (pp. 124–141) suffers from too extensive quotation together with lack of critical comment by the author. Some illustrations (*e.g.*, pls. 2, 3, 9, 19, 30, and others) add nothing to the text and should have been omitted. Finally the text should have been more rigorously edited to eliminate the rather frequent awkward phrasings that occur. This book could have been a monument in its subject; because of the features mentioned it has lesser status, but will serve as a partial account of the "clever coyote."—TRACY I. STORER.

RECENT PUBLICATIONS

Publications of the Institute of Marine Science, Univ. of Texas, Port Arkansas, Texas. Vol. II, No. 1. 1951.

Contains an important critical paper of general interest by Martin D. Burkenroad on "Some principles of marine fishery biology" and other research papers on marine annelids, foraminifera and assemblages of mollusks of the Gulf of Mexico.

The Common Loon in Minnesota. By Sigurd T. Olson and William H. Marshall. Occasional Papers: Number 5, Minnesota Museum of Natural History, University of Minnesota. University of Minnesota Press, Minneapolis. 77 pp. 1952.

Investigations of Woodcock, Snipe and Rails in 1951. By John W. Aldrich and others. Special Scientific Report—Wildlife No. 14, U. S. Fish and Wildlife Service, Washington, D. C. 58 pp. 1952. (Processed)

Mammal Survey of Southeastern Pennsylvania. By Harvey A. Roberts and Robert C. Early. Final Report, Pittman-Robertson Project 43-R. Pennsylvania Game Commission, Harrisburg, Pa. 70 pp. 1952.

Mammal Survey of Northwestern Pennsylvania. By Neil D. Richmond and Harry R. Rosland. Final Report, Pittman-Robertson Project 20-R. Pennsylvania Game Commission, Harrisburg, Pa. 67 pp. 1949.

Mammal Survey of Southwestern Pennsylvania. By William C. Grimm and Harvey A. Roberts. Final Report, Pittman-Robertson Project 24-R. Pennsylvania Game Commission, Harrisburg, Pa. 99 pp. 1950.

Mammal Survey of South Central Pennsylvania. By Clay L. Gifford and Ralph Whitebread. Final Report, Pittman-Robertson Project 38-R. Pennsylvania Game Commission, Harrisburg, Pa. 75 pp. 1951.

Mammal Survey of Northcentral Pennsylvania. By Harry R. Roslund. Final Report, Pittman-Robertson Project 37-R. Pennsylvania Game Commission, Harrisburg, Pa. 55 pp. 1951.

The Food of Predaceous Animals in Northeastern United States. By Roger M. Latham. Final Report, Pittman-Robertson Project 36-R, Report I. Pennsylvania Game Commission, Harrisburg, Pa. 68 pp. 1950.

The Ecology and Economics of Predator Management. By Roger M. Latham. Final Report, Pittman-Robertson Project 36-R, Report II. Pennsylvania Game Commission, Harrisburg, Pa. 96 pp. 1951.

Survey of Pennsylvania Migratory Waterfowl. By Carl R. Warren. Final Report, Pittman-Robertson Project 30-R. Pennsylvania Game Commission, Harrisburg, Pa. 35 pp. 1950.

Mammal Survey of Northeastern Pennsylvania. By William C. Grimm and Ralph Whitebread. Final Report, Pittman-Robertson Project 42-R. Pennsylvania Game Commission, Harrisburg, Pa. 82 pp. 1952.

Waterfowl Populations and Breeding Conditions —Summer 1951. By Walter F. Crissey and others. Special Scientific Report Wildlife No. 13. U. S. Fish and Wildlife Service, Washington, D. C. 240 pp. 1951.

This report is fifth in the annual series summarizing waterfowl breeding populations in the United States and Canada. It contains individual reports by different authors on investigations in 43 different areas, the total number of persons who have cooperated is obviously high in the hundreds, and the amount of quantitative information which has been assembled is most impressive. It would be difficult to name another aspect of wildlife management in which such gratifying progress has been made in the last six or eight years as that of waterfowl inventory and application of the results in determining hunting seasons.

An Analysis of the Pennsylvania Bounty System. By Roger M. Latham. Final Report, Pittman-Robertson Project 44-R, Pennsylvania Game Commission, Harrisburg, Pa. 35 pp. 1951. (Mimeographed)

BRIEFER ARTICLES

FOOD HABITS AND MEASUREMENTS OF HART MOUNTAIN ANTELOPE

Ellis Mason

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In January, 1950, representatives attending the Four-State Antelope Meeting at Lakeview expressed interest in conducting a comprehensive food habits study. The available literature revealed that stomach analyses had been largely confined to samples collected during the hunting season and information at other periods of the year was inadequate or lacking.

The Oregon Game Commission agreed to collect two to three antelope per month. Analyses of stomach contents were to be made by the Food Habits Laboratory of the California Division of Fish and Game.

The Hart Mountain Herd was selected for study since it contained the largest number of animals found in any single herd in the state and resides in habitat representative of typical antelope range. Cooperation was extended by the U. S. Fish and Wildlife Service in permitting the collection of animals on the Hart Mountain and Sheldon refuges when necessary. The Nevada Fish and Game Commission also extended authorization for collections south of the Oregon Line.

Collections were commenced on May 4, 1950, and terminated on April 19, 1951. A total of 26 stomach samples was analyzed. As far as practical, collections were made at monthly intervals unless weather or other factors interfered. Severe weather prevented access to the winter concentration area in January, 1951 and no animals were collected from December 11, 1950 to February 8, 1951. With the exception of two females taken in December, 1950, all collections were limited to bucks.

The Hart Mountain herd summers on or adjacent to the Hart Mountain Antelope Refuge and winters in the vicinity of Sagehen Flat and Big Spring Table southeast of the refuge along the Oregon-Nevada state line.

In addition to food habits analyses, field measurements of all specimens were taken.

Antelope Food Habits:

Table 1 summarizes food habits at monthly intervals. This breakdown is presented for rough comparative purposes only since collections were so few and were not all at the same time of the month.

Plant species are listed in the order of their occurrence by total volume. Those species representing traces are not tabulated. Sagebrush, particularly *Artemisia tridentata*, variety *arbuscula*, represents the most important yearlong food item on the Hart Mountain range. Sagebrush species make up approximately 61 per cent of the total diet and are represented each month. Ninety-six per cent of the stomachs collected contained some species of sagebrush. Eleven of the 26 stomachs examined contained over ninety per cent sage with three of the 11 containing 100 per cent sage.

Various species of *Phlox* comprised approximately 14 per cent of the total stomach contents and were found in 46 per cent of the samples. Varying percentages of Phlox were utilized during the spring and early summer months of April, May, June and July, followed by utilization again in November and December.

Forbs made up approximately six per cent of the total diet and were found in 19 percent of the stomachs. Use of forbs was confined to the spring and summer months of April, May, June and July.

The next most important item in the diet was bitterbrush (*Purshia tridentata*) which was utilized very heavily in July and lightly in August.

In descending order, those species representing over one per cent of the total diet included poverty weed (*Iva axillaris*), English plantain (*Plantago lanceolata*), Austin's Erigeron (*Erigeron Austinae*), sticky-flowered rabbit brush (*Chrysothamnus viscidiflorus*, clover (*Trifolium sp.*), and various species of green grasses. The majority of these species were utilized most heavily during July and August with the exception of green grasses, which were taken readily when available during the late fall and early spring months.

TABLE 1.—ANTELOPE FOOD HABITS AT MONTHLY INTERVALS

Plant Species and Groups	May, 1950 4 Samples	June, 1950 1 Sample	July, 1950 3 Samples	Aug., 1950 5 Samples	Sept., 1950 2 Samples	Nov., 1950 2 Samples	Dec., 1950 2 Samples	Feb., 1951 2 Samples	March, 1951 2 Samples	April, 1951 3 Samples	Year-Long Averages	
	Per cent of Total Volume	Per cent of Total Volume	Per cent of Total Volume	Per cent of Total Volume	Per cent of Total Volume	Per cent of Total Volume	Per cent of Total Volume	Per cent of Total Volume	Per cent of Total Volume	Per cent of Total Volume	% of Tot. Vol.	Fre %
Sagebrush, including *Artemisia tridentata* *A. t.* var. *arbuscula* *A. cana* *A. spinescens*	67.5	18.0	11.4	66.4	100.0	42.5	91.0	84.0	97.5	31.7	60.73	96.2
Phlox sp.	8.2	5.0	16.3			26.5	6.5			67.7	13.69	46.2
Forbs, including *Collinsia sp.* *Lupinus sp.* *Mertensia longiflora* *Viola sp.* *Balsamorphiza sp.* Compositae	10.0	75.0	14.7							0.6	6.19	19.2
Bitterbrush (*Purshia tridentata*)			36.3	1.0							4.38	11.5
Poverty weed (*Iva axillaris*)				16.0							3.08	7.7
English plantain (*Plantaga lanceolata*)			15.0	4.0							2.50	7.7
Austin's Erigeron (*Erigeron Austinae*)						31.0					2.38	3.8
Sticky-flowered rabbitbrush (*Chrysothamnus viscidiflorus*)				11.0							2.12	3.8
Clover (*Trifolium sp.*)	7.3										1.12	7.7
Grasses (green)	0.7						0.5	9.0	2.5		1.04	23.1
Desert parsley (*Lomatium sp.*)	5.0										0.77	3.8
Milk vetch (*Astragalus sp.*)	1.3		4.3								0.69	11.5
Grasses (dry)								6.5			0.50	7.7
Rabbitbrush (*C. nauseosus*)				0.8			2.0				0.31	11.5
Orthocarpus sp.			2.0								0.23	3.8
Fiddleneck (*Amsinckia sp.*)				0.8							0.15	3.8
Groundsel (*Senecio sp.*)		2.0									0.08	3.8
Shadscale (*Atriplex confertifolia*)								0.5			0.04	3.8

TABLE 2.—ANTELOPE WEIGHTS AND MEASUREMENTS

No.	Date	Area Collected	Sex	Live Weight	Age	Length	Height	Tail	Ear	Hind Foot	Spread	Left Horn	Right Horn
1	5/4/50	Antelope Buttes	M	100	2	53	33½	4	6	16½	11	10½	11
2	5/4/50	Antelope Buttes	M	65	1	49	33½	3	6	16	6	6	6
3	5/4/50	Sagehen Flat	M	110	Mat.	54	36	4½	6	17	13	11½	11½
4	5/25/50	Wire Corral Flat	M	115	Mat.	52	38	4½	6½	17	9½	11½	12
5	6/7/50	Spanish Flat	M	140	Mat.	52	38½	4	6½	17½	12	14	14
6	7/3/50	Upper Rock Creek	M	140	Mat.	53	38	4	6½	17½	12½	13	13
7	7/3/50	Upper Rock Creek	M	125	2	54½	39	4	6	17½	10	11	11
8	7/3/50	Wire Corral Flat	M	135	Mat.	53	37	4	6½	17	11	13	13
9	8/1/50	Hart Mountain	M	130	Mat.	58	37	4	6	17	12	13	13
10	8/1/50	Hart Mountain	M	135	Mat.	57	36	3½	6	16½	15	13	12
11	8/2/50	Hart Mountain	M	125	Mat.	56	35	4	6	17	11	12	11
12	8/22/50	Hart Mountain	M	130	Mat.	50	38	4½	5½	16½	12½	13½	13½
13	8/22/50	Hart Mountain	M	140	Mat.	52	41	5	6	17	12½	14½	15
14	9/22/50	Hart Mountain	M	...	Mat.	53	37	..	6	..	..	12	12
15	9/22/50	Hart Mountain	M	...	Mat.	50	37½	..	6½	..	..	15	15
16	11/3/50	Sagehen Flat	M	125	Mat.	54	37	4	6	17	13	13	14
17	11/3/50	Sagehen Flat	M	130	Mat.	53	37	4	6	17	12	12	11
18	12/11/50	Sagehen Flat	F	105	Mat.	50½	36	4	6	16½	..	2	2
19	12/11/50	Sagehen Flat	F	95	1½	51	36	4	6½	16½	..	1	1½
20	2/8/51	Knot Creek	M	105	2	53	37	4	6	16	11	9	10½
21	2/8/51	Knot Creek	M	100	Mat.	52	38	4	6	16½	12	9	10½
22	3/25/51	Big Spring Table	M	130	Mat.	51	39	4	6	17½	11	10	10
23	3/25/51	Big Spring Table	M	140	Mat.	47	36	4	6	16½	14	15½	15½
24	4/19/51	Antelope Buttes	M	110	Mat.	54	37	4	6	17	10	10	11
25	4/19/51	Antelope Buttes	M	65	1	44	36	3½	6	16	6	4	4
26	4/19/51	Antelope Buttes	M	70	1	46	35	3	6	16	6½	4½	5

Green grass represented slightly over one per cent of the total diet while dry grass made up but one-half of one per cent. The total consumption of grass and forb species that are preferred by domestic livestock is extremely limited. Direct competition with domestic livestock for individual plant species is slight and evidence indicated that substantial increases of antelope numbers can be maintained on this range without conflict.

Measurements:

Measurements of physical characteristics are summarized in Table 2.

All measurements were taped according to standard procedure and recorded in inches. Total weights were recorded and are fairly accurate, subject only to variable losses of blood.

Of the 26 animals collected, 24 were males and two females. The collection included three males and one female from one to two years of age, two males from two to three years of age, and the remaining animals were considered mature, that is three years or older.

The live weight of mature bucks varied from 100 pounds to 140 pounds. Although the 100-pound male was collected in February, it is significant that one of the four bucks which weighed 140 pounds was taken in March.

The total length of mature bucks averaged 52.9 inches with a variation from 47 inches to 58 inches. Shoulder height averaged 37.4 inches with a variation from 35 to 41 inches. Since lengths of tail, ear, and hind foot were recorded in inches and appear uniform, maximum and minimum measurements are not significant. An inadequate number of samples for immature males and for all females does not justify comparisons.

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DEER REPELLENT SPRAYS NOT HARMFUL TO FOLIAGE ON TWO-YEAR-OLD TREES

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and California Department of Fish and Game, San Francisco

Deer damage to crops is common in California and many techniques have been employed to combat this condition. Deer proof fencing (Storer and True, 1931) is still one of the most effective methods for control but installation and maintenance are expensive. The use of deer repellents is lower in cost and newly developed products offer protection in varying degrees (Baumgartner and Powell, 1949; Welch, 1950). Agriculturists often have been reticent to attempt this method of control, however, because of possible damage by

TABLE 1.—REPELLENTS USED AND METHODS OF SPRAYING EXPERIMENTAL TREES

Number of times each tree sprayed	Repellent	Strength of repellent used	Variety of tree (Total of 85 trees.) Gravenstein apple	Yellow delicious apple	Royal apricot	Tilton apricot	Winter Nelis pear	Elberta peach	Bosc pear	Quince	Marianna plum 2624	Bing cherry	Mazzard cherry	Mahaleb cherry	President plum	Duarte plum	Nonpareil almond
SIX [1]	Diamond L Brand	Recommended		1		1			1		1			1			
		Double						1	1					2			2
	Good-rite z.i.p.	Recommended	1		1		1	1		1		1			1		
		Double		1							1			1			
	Mapco	Recommended	1		1		1	1				1			1		
		Double		1										1		1*	
	Mapco plus adhesive [4]	Recommended	1		1		1†	1		1			1		1		
		Double		1										1			
THREE [2]	Good-rite z.i.p.	Recommended		1		1		1	1		1		1				
		Double	1		1		1	1		1		1			1		
	Mapco	Recommended		1		1		1	1		1			1			
		Double												1‡			
	Mapco plus adhesive [4]	Recommended		1				1	1		1			1			
		Double	1		1		1	1		1		1			1		
THREE [3]	Diamond L Brand	Recommended	1			1	1	1					1				
		Double												1		1	
CONTROLS	(not sprayed)		1			1				1		1	1		1	1	
TOTAL OF EACH VARIETY OF TREE.....			7	7	5	5	6	10	5	5	5	5	4	10	6	3	2

[1] Sprayed at intervals of two weeks: March 14, 31; April 13; May 2, 16; and June 1, 1950.
[2] Sprayed at intervals of one month: March 14, April 13; and May 16, 1950.
[3] Sprayed at intervals of both one month and two weeks: March 31, May 2 and 16, 1950.
[4] Not available commercially.
* In addition to indicated spraying with Mapco, also sprayed with recommended strength of Diamond L Brand on March 31, May 2, and May 16.
† Sprayed on both May 16 and May 17.
‡ On March 14 also sprayed with double strength Mapco plus adhesive.

repellent sprays to the foliage of trees requiring protection.

This experiment was designed to evaluate possible foliage damage by utilizing commercially available deer repellents (Table 1). Normal frequency of spraying based on new leader growth and twice the normal frequency was employed in conducting these tests. Many of the trees were sprayed with a solution that was double the strength recommended by the manufacturers as being adequate to repel deer, in order to make certain that the repellents would not cause foliage damage. Frank M. Kozlik of the California Division of Fish and Game assisted in the spraying operations.

The 83 fruit and 2 almond trees used in the tests were planted at Davis in April, 1948, by the Division of Pomology for repellent studies. Most of the two-year-old trees were first sprayed on March 14, 1950, the remainder on March 31. On March 31 all of the trees had at least a few leaves and the following kinds were well foliated: Royal apricot, Tilton apricot, Elberta peach, quince, Marianna plum 2624, Duarte plum, and Nonpareil almond. By April 13 all trees had many leaves. The experimental trees were planted close together to save space. To avoid contamination of adjacent trees, each tree was enclosed with part of a nylon parachute while being sprayed; in consequence the trees probably received more spray and more complete coverage than would trees sprayed in open stands.

No foliage was noticeably injured on any of the 78 treated trees (Table 1), including those sprayed every two weeks at double the recommended strength and those sprayed more often and with two kinds of spray. Richard W. Harris and Eugene W. Stiles, both of the Division of Pomology, University of California, examined the trees at the conclusion of the experiment and agreed that the foliage showed little if any damage from the repellents. Many leaves exhibited some insect damage and wind burn, but this also was true on the unsprayed controls.

To protect trees from deer, they may have to be re-treated as new leaves appear—the frequency will depend on the rate of leader growth, the number of deer present, and the availability of natural browse. In any event, spraying probably would not be at more frequent intervals than with some of the trees in this experiment.

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WATERFOWL SEX RATIOS OBSERVED IN THE WESTERN UNITED STATES

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Based on the line of reasoning expressed by Dr. Cottam in "Some Improvements Needed in Wildlife Research" (Jour. Wildl. Mgt., 11: 339–347, 1947), the following data on waterfowl sex ratios are contributed with the hope that, instead of remaining buried in my notes, they may provide information helpful in the interpretation of waterfowl management problems. These data have been taken from a nine-year (1942–1951) accumulation of personal field notes. The majority of the records for Oregon were made during the years 1946–1948, and the California records were obtained during the years 1948–1951.

Records of both adult and immature "dabblers" are included only for those periods when sexual plumage differences could be distinguished accurately. Only adult "divers" that could be definitely identified as to sex are included, regardless of the season. In most cases,

identifications were made with the aid of 7x35 binoculars. The data are based on the following number of individuals of each species: mallard, 6,810; green-winged teal, 90; blue-winged teal, 8; cinnamon teal, 1,172; pintail, 4,709; gadwall, 271; baldpate, 2,088; shoveler, 3,190; wood duck, 251; redhead, 70; ring-necked duck, 705; canvasback, 483; scaup (mostly Lesser), 429; common golden-eye, 41; Barrow's golden-eye, 6; ruddy duck, 208; common merganser, 121; and red-breasted merganser, 32.

The most significant data are available for the mallard, pintail, and shoveler, and are presented by months in Table 1.

From the totals in Table 1, sex ratios also can be determined by states. For the mallard: 127 males per 100 females in Oregon; 124:100 in California; and 130:100 in Nevada. For the pintail: 135:100 in Oregon; 195:100 in California; and 91:100 in Nevada. For the shoveler: 145:100 in Oregon; 229:100 in California; and 25:100 in Nevada.

Table 2 presents the sex ratios, listed by States, for 18 species of ducks.

Data on mallards compare favorably with the direct-count findings of Yocom (A Study of Sex Ratios of Mallards in the State of Washington. Condor 51: 222–227, 1949). Table 2 shows apparently exaggerated discrepancies in the sex ratios for blue-winged teal, wood duck, shoveler, redhead, ring-necked duck, scaup, common golden-eye, ruddy duck, common merganser, and red-breasted merganser.

TABLE 1.—MONTHLY SEX RATIOS OF MALLARDS, PINTAILS, AND SHOVELERS IN OREGON, CALIFORNIA, AND NEVADA

Species and Months	Oregon		California		Nevada		Totals		Sex Ratios
	M	F	M	F	M	F	M	F	M F
MALLARD									
October			53	25			53	25	212:100
November	36	34	28	13			64	47	136:100
December	1	1	146	125			147	126	117:100
January	1020	472	50	45	73	57	1143	574	199:100
February	875	795	45	42			920	837	110:100
March	873	842	92	78			965	920	105:100
April	301	301	54	39			355	340	104:100
May	16	16	48	36	22	18	86	70	123:100
June	3	3	60	60	8	4	71	67	106:100
Totals	3125	2464	576	463	103	79	3804	3006	126:100
PINTAIL									
October			43	27			43	27	159:100
November	3	1	6	0			9	1	900:100
December			15	9			15	9	167:100
January	994	658	7	5			1001	663	151:100
February	505	480	6	1			511	481	106:100
March	357	316	1	0			358	316	113:100
April	757	488	3	0	10	11	770	499	154:100
May	1	1	3	1			4	2	200:100
Totals	2617	1944	84	43	10	11	2711	1998	136:100
SHOVELER									
November	14	8	7	2			21	10	210:100
December			10	11	1	4	11	15	73:100
January	44	24	1	3			45	27	167:100
February	730	680	43	67			773	747	103:100
March	373	211					373	211	177:100
April	481	215	189	26			670	241	278:100
May	27	16					27	16	169:100
June			2	1			2	1	200:100
Totals	1669	1154	252	110	1	4	1922	1268	152:100

TABLE 2.—WATERFOWL SEX RATIOS, BY STATES

Species	Idaho	Oregon	California	Nevada	Arizona	Totals	Ratios
Mallard		3125:2464	576:463	103:79		3804:3006	126
Green-winged Teal		7:4	1:1	1:1	40:35	49:41	120
Blue-winged Teal		5:3				5:3	166
Cinnamon Teal		37:30	513:494	31:16	26:25	607:565	107
Pintail		2617:1944	84:43	10:11		2711:1998	136
Baldpate	815:786	16:14	198:234	9:11	2:3	1040:1048	99
Gadwall		6:5		103:103	27:27	136:135	101
Shoveler		1669:1154	252:110	1:4		1922:1268	152
Wood Duck	2:2	116:73	31:27			149:102	146
Redhead			13:11	16:16	4:10	33:37	89
Ring-necked Duck		21:13	406:265			427:278	154
Canvasback		71:38	196:174	2:2		269:214	126
Scaup		26:22	250:121	3:2	2:3	281:148	190
Common Golden-eye		2:0	23:8	3:4	1:0	29:12	242
Barrow Golden-eye		3:3				3:3	100
Ruddy Duck		10:21	25:56	48:48		83:125	66
Common Merganser		28:17	45:21	6:3	1:0	80:41	195
Red-brstd. Merganser		20:12				20:12	167

Lack of sufficient sampling data may be the logical explanation for the discrepancies for most of these species. However, large differences have been observed many, many times in the field for the shoveler, ring-necked duck and the scaup. Some other explanation of the observed sex ratios must be forthcoming for these three species. Since Hochbaum (The Canvasback on a Prairie Marsh, Amer. Wildl. Instit., 149–153, 1944) has given a thorough discussion of possible explanations, it does not seem necessary to go into a similar discussion in this brief paper.

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COVE SELECTION AND USE OF GILL NETS IN FISH POPULATION SURVEYS IN LARGE IMPOUNDMENTS[1]

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Summer Survey,[2] Oklahoma Game and Fish Department, Oklahoma City, Oklahoma and Department of Zoology, University of Oklahoma

INTRODUCTION

Oklahoma now has over 300,000 acres of water in bodies more than five acres in size. These waters are almost entirely man-made and are used for water supply, flood control and recreational purposes. In 1950, over half a million dollars were derived from the sale of fishing licenses within the state. To provide and maintain the good fishing which fishermen demand, lakes and ponds must be managed.

Before fish management practices can be recommended for large lakes, information on the age, growth and population balance should be sought. In the Oklahoma surveys the fish populations were sampled with rotenone and gill nets in a number of coves around the periphery of the lakes.

Fish poisons have been used effectively and widely in fish management. Solman (1950) reports that some form of rotenone has been used to date in thirty-four states. These poisons are employed for complete eradication of an un-

[1] The author wishes to acknowledge the equipment and facilities provided by the Fisheries Research Laboratory and the Zoology Department of the University of Oklahoma. To Mr. H. C. Ward, Director of Fisheries, who supervised the work and to Kermit Sneed, Gordon Hall, Mayo Martin and Bill Burris, members of the survey, thanks are extended.

[2] The Summer Survey was a cooperative project between the Oklahoma Game and Fish Department and the University of Oklahoma Biological Survey.

desirable fish population, for reduction of predator or competitor species and as a research tool in growth-rate, population or taxonomic studies (Miller, 1950).

During the summer of 1950 the Oklahoma Game and Fish Department used rotenone in a fish population survey of ten of the larger impoundments within the state (Table 1). This report deals with the experience and results in conducting the survey. Many of the problems differed widely from those encountered from the use of rotenone in small ponds and lakes.

COVE SELECTION

All coves are not suitable for sampling the fish population with rotenone. A number of points were observed in the selection of a cove, namely: accessibility, size and shape, shoreline, wind exposure and present direction, age and position of the cove in the lake, fishing reports and aquatic vegetation. Ideally, all these things should be considered, and the coves chosen should be representative of the lake's production. In the present investigation certain factors took precedence over others mainly for their practicality. Accessibility to the area with trucks and trailers was probably the major consideration, although on one occasion it was necessary to reach a cove by boat.

TABLE 1.—THE IMPOUNDMENTS SURVEYED DURING JUNE AND JULY, 1951. LAKE CARLTON AND STRINGTOWN PRISON LAKE AND ADDITIONAL COVES IN THE OTHER LAKES WERE ALSO STUDIED

Name of Lake	Total[1] Acreage	Cove Acreage	Max. Depth Cove Feet	Amount of Rotenone Pounds
Guthrie Country Club..	45	2	8	30
Clinton.....	335	2.5	6	30
Okmulgee.....	643	2.5	10	30
		2	16	50
Altus-Lugert.....	6,806	5	8	50
Greenleaf.....	920	3	8	30
		1.5	3	15
Fort Supply.....	1,750	1	5	15
		2.5	9	35
Lake Murray.....	5,728	4.5	18	50
		1.5	16	30
		2.5	9	30
Goddard.....	27	25	29	200

[1] Planning and Resources Board (1946).

A shoreline with a gentle enough slope and a clearing to permit the passage of vehicle was sought. The size of the cove which could be sampled was limited by the type of gear, the size of the crew, and the available time. A good many of the coves surveyed were approximately 2 to 5 surface acres. Most shapes were satisfactory, provided that the width of the cove permitted the setting of gill nets from shore to shore, a distance not greater than 75 to 100 yards. Widemouthed coves were exposed from many directions to water currents which frequently flushed out the rotenone. Consequently, coves with the narrowest mouths were sought. The desired depth of the water at the mouth of the cove was not greater than eight feet, corresponding to the depth of the gill nets stretched across the mouth from top to bottom. Further, it was observed that the shallower the cove, the quicker the rotenone reached the bottom and the less chance there was for it to be flushed out before it settled completely. However, coves as shallow as two feet were undesirable because of their meager fish populations. A cove protected from the wind and one that had its longitudinal axis so oriented that it did not give the wind a full sweep down its length was most satisfactory. Coves situated at the ends of the lake were subjected to greater water movement due to the existence of longitudinal seiches. An impoundment serving its function in flood control is subjected to much water fluctuation. Conditions were encountered where the level of the lake had temporarily risen as much as fifteen feet and suitable coves were extremely difficult to find among those recently inundated. The fish population in these coves was found to be extremely small, a fact probably accounted for by the conditions accompanying the decomposition of the recently submerged grass and plants and by the scattering of the fish in the flood waters. In general, coves less than a year old had bottoms that contained unusually large amounts of organic matter deposited by the vegetation cover before inundation. Such coves and especially the protected ones never seemed to support a fish population that made sampling worth while. In coves that had a steep heavily wooded shoreline, the leaves of the trees were either blown onto the water or washed down the slopes of the bluff into the water, depositing organic matter on the bot-

tom; the high temperatures promoted decay especially in shallow water. Following the principle that the shallow water areas of a lake are generally more productive than the deeper waters, greater quantities of fish were usually found in the shallow water areas at the head, rather than at the foot of the lake.

THE USE OF GILL NETS

It soon became evident that a gill net, completely covering the mouth of the cove, would help prevent fish from entering or leaving the cove. The data collected from the use of gill nets also would be useful in evaluating the completeness of the kill.

Although it seems unlikely that all fish attempting to leave or enter the cove were caught in a gill net, the netted fish indicated the magnitude of the fish movement. Gill net data from Greenleaf Lake[1] revealed that fish did move in and out of the cove (Table 2). During the three days of operations in the cove, 206 fish were netted of which 93 fish were caught on the inside of the net and 113 on the outside. It should be noted that 5 hours after applying the rotenone more fish were caught leaving than entering the cove. At Lake Altus gill net data, collected 2 hours after the application of the poison, indicated 24 fish leaving for 3 entering. In another cove in the same lake, a gill net lifted 24 hours after poisoning contained 109 fish leaving as opposed to 65 entering. Similar observations were obtained from gill nets set in other lakes.

These observations were important from a number of standpoints. First, the idea that fish could and did move in and out of the cove during our rotenone operations was substantiated. Second, the fact that fish were caught attempting to move out of the cove 24 and 48 hours after rotenoning suggested an incomplete kill. However, one never could be absolutely certain that fish were not able to slip into the cove past the gill net and be caught in the gill net on the way out. An incomplete kill was not surprising for it was known that many surface and subsurface currents were present and thus rotenone could be easily swept out

[1] Gill nets were used in many coves in various lakes and the data from Greenleaf Lake are used as an example. The size of mesh varied from 1 to 2½ inches but 1½ inches was most commonly employed.

TABLE 2.—NUMBER OF FISH CAPTURED ON THE INSIDE AND THE OUTSIDE OF A GILL NET SET ACROSS A COVE IN GREENLEAF LAKE—JULY, 1951, DURING ROTENONE STUDIES. LIFT #1 WAS AT 3:00 P.M., FIVE HOURS AFTER ROTENONING; LIFT #2 AT 10:30 A.M., 24 HOURS AFTER; LIFT #3 AT 9:30 A.M., 47 HOURS AFTER POISONING

Species (Chute *et al.*, 1948)	Lift #1 In	Lift #1 Out	Lift #2 In	Lift #2 Out	Lift #3 In	Lift #3 Out
Bluegill	12	19	12	31	5	3
Crappie	1	..	12	11	9	..
Longear Sunfish	..	3	3	..	..	1
Largemouth Black Bass	1	..	4	7	..	..
Green Sunfish	..	1	3	2	2	3
Warmouth	1	1	1	1	1	..
Redear Sunfish	..	2	2	1	..	..
Gizzard Shad	1	..	..	1	1	..
Spotted Sucker	1	..	1	..	1	..
Channel Catfish	..	2	4	1	15	20
Spotted Gar	..	..	1	1	..	..
Freshwater Drum	..	1	..	..	..	..
Total Number Fish	16	30	43	56	34	27

of the cove before it had time to settle to the bottom waters. Fish in the bottom waters would still be alive. Such currents were evidenced by fish kills far out into the lake. The gill net stretched across the mouth of the cove prevented dead or incapacitated fish from being swept out of the cove by the currents.

In the case of an incomplete kill, gill net data helped to reveal the kinds of fish not killed. When gill net catches were analyzed by species and these data compared with the species composition of the kill, it was found in some instances that more fish of a certain kind were caught by gill nets than by rotenone. At Altus the total number of carp-suckers taken from the cove during our survey the first day was fourteen; of these, three were collected with rotenone, eight were taken from the inside of the net and three from the outside of the net. This was an indication that the rotenone did not reach the bottom where the carp-suckers were found. Water samples were collected eighteen hours after poisoning at the surface and directly above the bottom at four stations within the cove. Young gizzard shad, carp, bass, and red shiners were put into each of these samples and the results from these experiments suggested that rotenone was not in strong enough concentrations to kill fish in the deeper water of the cove, but was present in

lethal concentrations to the experimental fish in the surface and the bottom waters at the other three shallow water stations. These experiments were run for one hour at 26°C. Controls were used.

The numbers and pounds of fish lost or gained with no gill net across the cove may be very small in comparison to the total recovery of the cove. In most cases the gill net catch was less than one percent (going as high as 3% in the case of rough fish) of the total number taken in an area. The number actually leaving a cove is probably greater, for the gill net is a poor method of capture. However, when species compositions are sought there may be an appreciable number of one kind of fish lost by migration out of the cove.

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NOTES ON THE FOOD OF FUR SEAL, SEA-LION, AND HARBOR PORPOISE

Ford Wilke and Karl W. Kenyon

Aside from its interest to naturalists, the food of marine mammals is of direct concern to the fishing industry and conservation agencies. Our knowledge of the food of even such a commercially important mammal as the northern fur seal (*Callorhinus ursinus*) is surprisingly incomplete. Almost no studies have been made of their feeding habits on the vast wintering grounds off California, Oregon, and southern Washington (Scheffer, 1950; Hanna, 1951). Despite widespread condemnation of the northern sea-lion (*Eumetopias jubata*) by fishermen, its food has not yet been accurately determined. Imler and Sarber (1947), who made the most extensive investigation in Alaska, examined only 15 stomachs containing food.

The following notes will add a few facts to the compilation of a geographically and seasonally complete record of the food of three common marine mammals.

Fur seals.—In March 1950, 42 fur seal stomachs were collected with the aid of cooperating native hunters in West Crawfish Inlet, near Sitka, Alaska. In January 1951 another series of 106 stomachs was obtained from the same inlet. Lured by the abundant herring, mature female seals assemble in West Crawfish Inlet from December until late March, with the peak of abundance during late January and February. The surface water temperature in January is 37–38° F., somewhat colder than the usual offshore surface temperature in areas where female seals are wintering. The stomach contents of 148 seals were:

Herring, *Clupea pallasii*.....99.5 percent
Pollack, *Theragra chalcogramma* 0.5 percent
Squids, *Loligo* sp..... trace

The average weight of the contents was around two pounds. Various amounts of stomach contents occurred as follows:

Pounds	1 or less	1–2	2–3	3–4	4–5
Frequency	34	9	16	14	11
Pounds	5–6	6–7	7–8	8–9	9+
Frequency	6	8	4	1	1

Total—104

The greatest number of herring in any stomach examined was 39; the average number was 7.6. Forty-four stomachs were completely empty except for the ever-present roundworms. Three stomachs contained granitic and basaltic pebbles. Stones are usually found in seal stomachs on the Pribilof Islands but almost never when the animals are on the open sea (Austin and Wilke, 1950). Scheffer (1950) concluded from a compilation of all existing data on fur seal food habits that herring is the principal food of the fur seals during their northward migration near the coast in the spring. Our examinations

suggest that herring constitutes the bulk of the winter diet in inshore Alaskan waters.

Jordan (1898) observed what he called the "spewings" of seals on the Pribilof rookeries and noted that they were composed of pollack. Although seldom mentioned, disgorged material consisting largely of bones but including some flesh is seen frequently on the rookeries and hauling grounds. On 30 June 1951 at Reef rookery a bull disgorged the remains of three pollack, each over 15 inches long. Bones ejected by a subadult bull on the same rookery on 20 July represented about 25 pollack. Evidence from the food remains on the Pribilof rookeries is that fur seals depend to a large degree on small fishes of the family Gadidae during their stay in the Bering Sea. Numerous otoliths of gadids may be found scattered about in the rookery sands and embedded in the hard packed earth of the rookeries. Of about 50 otoliths gathered on St. George in 1950 almost all were from pollack. Over 500 otoliths from St. Paul were nearly all from small gadids ranging in length from four or five inches to a foot. About 20 pollack otoliths were included in the latter group.

Northern sea-lion.—Food studies of northern sea-lions, as of all the Otaridae, are hampered by the fact that most animals shot on the beach have empty stomachs. According to our experience, nursing females are most apt to have full stomachs. One collected by Victor B. Scheffer and Karl W. Kenyon in July 1949 on St. Paul Island had in its stomach ten pounds of fish of the following species:

Sand lance, *Ammodytes tobianus personatus*	99.7 percent
Starry flounder, *Platichthys stellatus*	0.3 percent
Sculpin skull, probably *Myozocephalus*	trace

Another female collected by Ford Wilke and O. Wilford Olsen in 1951 on St. Paul Island had 20 pounds of fish in its stomach in addition to four large stones. Included in the contents were:

1 halibut, *Hippoglossus stenolepsis*, original size 25–30 pounds	70 percent
10 flounders, *Pleuronectidae*	5 percent
4 cod, *Gadus macrocephalus*	15 percent
3 pollack, *Theragra chalcogramma*	10 percent

Of 20 sea-lions of all ages taken for hookworm examinations in 1951, the only other one containing food had only a large cephalopod beak remaining in its stomach.

Harbor porpoise.—A female harbor porpoise, *Phocoena vomerina*, killed by an underwater detonation, was collected by Capt. C. E. Taylor near Port Townsend, Washington, in May 1950. The stomach of this animal contained the remains of five herring.

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A SUGGESTED FOOD RANK INDEX

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In a recent ecologic investigation of the wild turkey (*Meleagris gallopavo intermedius*) on the King Ranch area of south Texas a study of the food habits of the species received considerable attention. Crops taken during each month of the year were examined. The results will be presented in a later report. During the actual analysis and the subsequent study of the data, some weaknesses in the standard methods of presentation of food habits data became apparent. This led to the derivation of a formula using the principal measurable factors involved in food habits data. These factors are volume, weight, and occurrence.

A standard method of presenting food habits data is by percentage volume. This entails the addition of the percentage of the volume of each food item in each examined stomach, after which the total percentage is divided by the number of stomachs examined in that period to give a percentage number. This method used alone does not take into consideration either the relative weight of that food or the number of times that that food occurs in a given series of stomachs. When dealing with the importance of a food, the relative weight and occurrence are both important items.

Gross volume is another method of presenting food habits data, which involves the addition of the volume of each food item in all crops (stomachs) and the division of this figure by the total volume of all of the items in all of the crops in the period to arrive at the actual gross percentage. This method gives a distorted view of food habits because, by itself, it does not take into consideration the relative sizes of the crops, the relative amounts of the food taken, the relative weights of the food items, nor the occurrence of the food items.

The percentage weight is arrived at in the same manner as the percentage volume figure, and it also gives a poor picture of food habits, when used alone, because it does not take into consideration the relative volume nor the occurrence of the foods.

The number of crops in which a food occurs is important in determining the distribution, acceptability, and possible availability of a food item. For instance, a crop consisting of a single food item would appear more important in a volumetric table than a different food item that occurred in smaller percentages in a number of crops. Such should not be the case as a single crop should receive no more importance than any other crop, regardless of volume. The food of seemingly lesser importance would actually be of greater importance to more birds. Conversely, the volume of a food in a crop is a reasonable index of the importance of that food to that bird. Since all birds can not be examined in any one area, the volume of that food is often an important index to the acceptability and/or, availability of that particular food in a given area. It is felt that percentage volume and occurrence are of equal importance and that both factors are necessary to an understanding of a food's importance.

When all of the above methods of food habits presentation are placed side by side in a series of tables, a better picture can be obtained of the importance of the various food items. These tables are lengthy, however, and to the untrained person they constitute a mass of formidable statistics.

To present all of these aspects of a food in one table, an index formula has been developed, which takes into consideration percentage volume, relative weight and the percentage occurrence. This formula is:

$$x \cdot y \cdot z = R$$

Where

- x = % volume of the food (expressed as a decimal) times 100
- y = % of occurrence of the food (expressed as a decimal)
- z = the specific gravity of the food *
- R = The Index number

For the sake of example, two applications follow:

* Many thanks to Dr. A. M. Stebler, Unit leader of the Okla. Coop. Wldf. Res. Unit at Okla. A. & M. College and to Dr. L. W. Johnson, Head of the Mathematics Dept. at Okla. A. & M. College for editing this paper.

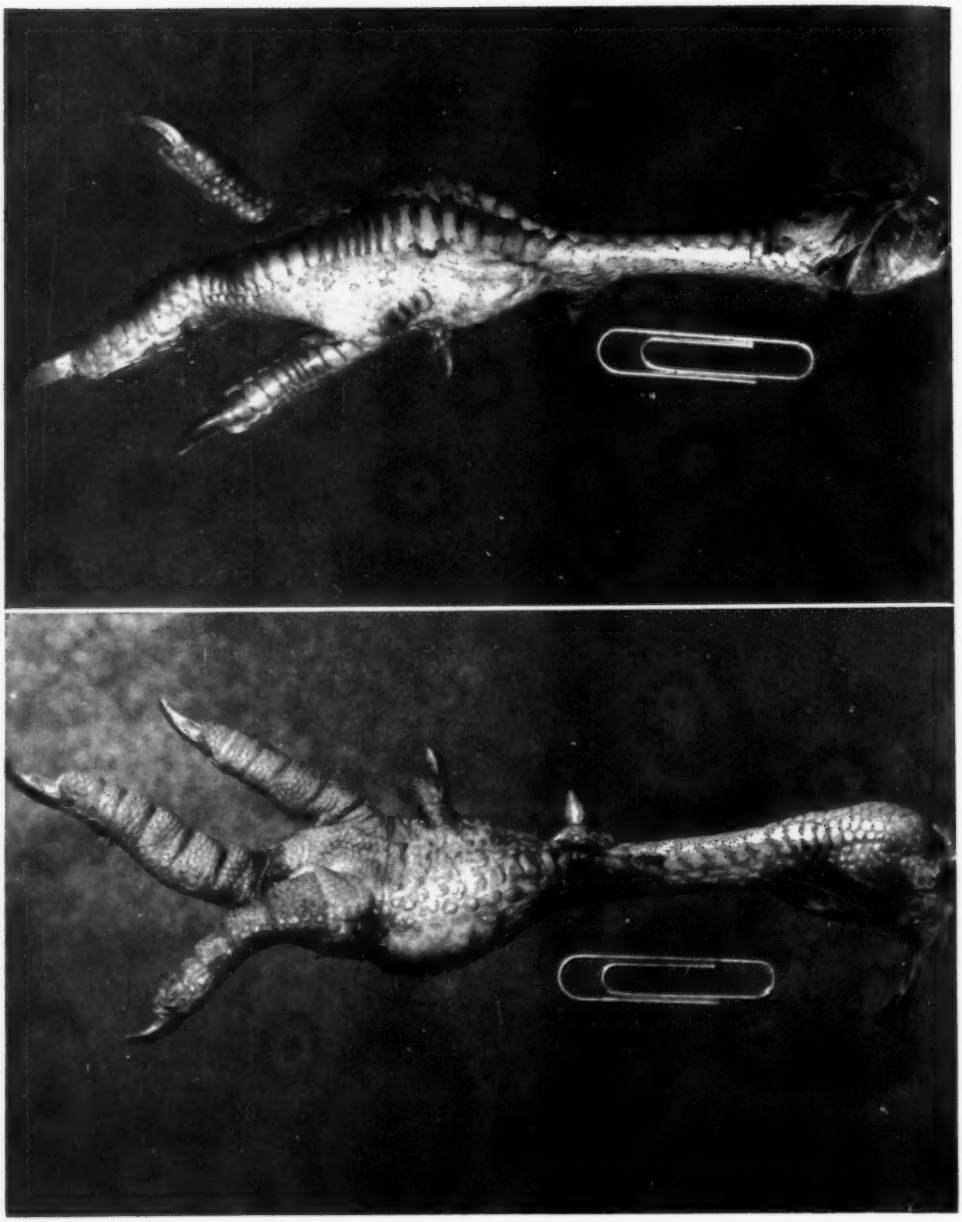

PLATE 8. A case of bumble foot in the ring-necked pheasant.

	% Volume (x)	% Occurrence (y)	Specific Gravity (z)	Index No. (R)
Acorns.....	(.20) 100 ×	.50 ×	.64 equals	6.4
Panic grass seed.....	(.10) 100 ×	1.00 ×	.43 equals	4.3

To arrive at the index number for more than one month, the indices of each item are added for each month considered. If the number of crops taken in each month is the same, the index can be worked out for all months together and need not be added month by month.

This formula does not take into consideration the availability or the acceptability of a food item which are also important in food habits studies. Either or both of these factors could easily be added to the basic formula in the event that they should be reduced to mathematical expressions. This formula is used to provide a better picture of the relative importance of food items and to provide a basic formula for use in further food habits studies in regard to nutrition, acceptability, and availability.

Nutritional values or factors are not considered in this work because few foods of wild turkeys have been studied from a nutritional standpoint, and because the nutritional requirements of turkeys are not thoroughly known. The latter is due partially to individual and seasonal variation. It should also be taken into account that any food in an area, at a given time, might not meet the nutritional requirements of the animal, and yet, this food could be the most important in that area because it was one of a few which was present in any quantity.

Some people may contend that the use of a specific gravity factor would overemphasize and/or, minimize foods as to nutritional value. Such is not the case; the specific gravity (or density) of the food item is incorporated in this formula because it is felt that the relative amount by weight of a food taken is of some importance in determining the relative rank of the food item in relation to other food items; and it is important to include the specific gravity or density in the index here presented in order to convert it from a volumetric to a gravimetric basis. This was done because of certain basic inaccuracies in volumetric measurement, and because studies dealing with nutrition are on a gravimetric basis. It is also felt that other workers may be able to use this index formula by itself or as a basis for coordinating existing food habits studies with nutritional, availability, or acceptability studies.

* Various samples of a food item should be weighed to determine the average specific gravity because it varies somewhat due to season, maturity, dryness, etc.

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A CASE OF BUMBLEFOOT IN THE RING-NECKED PHEASANT

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On October 24th, 1950, 2,750 male pheasants were aged and weighed by State Game Biologists at the National Tea Company's Locker Plant at Hopkins, Minnesota. The birds were contributed by Minnesota hunters for the Veterans' pheasant dinner held annually at the Fort Snelling Veterans Hospital.

Two of the pheasants, an immature male and an adult male, had much enlarged feet. See Plate 8. The feet were removed and submitted to Dr. R. Fenstermacher, Division of Veterinary Medicine, University of Minnesota, for examination. Dr. Fenstermacher diagnosed the condition as bumblefoot and stated that bumblefoot is usually caused by soil anaerobes which gain access through foot lesions. In addition, however, urates were found in the feet indicating the possibility of a Vitamin A deficiency.

Although a partial check was made of the literature, no mention of bumblefoot in pheasants was found.

Accepted for publication Oct. 27, 1951.

A LATE BREEDING RECORD FOR THE WHITE-TAILED DEER

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A white-tailed deer fetus was removed from a doe killed by a car in Itasca County, Minnesota, on the night of September 26th, 1950. The fawn was brought to St. Paul by Warden Bob Greig, for examination.

Measurements of the fawn were taken according to Armstrong (Fetal Development of the Northern White-tailed Deer *Odocoileus virginianus borealis* Miller), American Midland Naturalist, **43**: 650–666, 1950). The age of the fawn—181–200 days—was determined by a key given in Armstrong's paper.

Measurements were as follows: crown-rump, 437.5 mm.; forehead-rump, 537.5 mm.; hind-foot, 155 mm.; ear, 61 mm.; weight, 1,289.9 grams. Vibrissae, well-developed. The fetus was shaped like an adult. The hair covering was complete as was the white spotting of the coat. The incisors and premolars seemed entirely barred of their membrane.

The only discrepancy was the weight—1,289.9 grams. According to Armstrong, a fetus 181–200 days old should weigh 2,430 to 2,702 grams. Perhaps, the fawn had lost weight when the mother was crushed and killed by the car. The fawn's own skull was crushed and the hind leg broken.

If the fawn were approximately 181 days old, the doe must have been bred about March 29th. If the fawn were 200 days old, the doe must have been bred about March 10th.

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NOTES AND NEWS

Society members attending the last meeting in March, 1952 will recall that the Council approved appointment of an Executive Secretary as provided by the Constitution. A budget of not more than $600 per year was approved to cover clerical help needed by the Executive Secretary.

According to Article IV of the Constitution, "The Executive Secretary shall be appointed by a two-thirds vote of the Council. . . . The combining of the offices of Secretary and Treasurer shall take place at the end of the annual meeting, of same year, and a notice of such a union shall be made to the membership at least six months prior to the change." Actually the final decision as to whether the two offices are to be combined will have to be made prior to September 1 so that the Nominating Committee will know whether or not to submit nominees for Secretary.

Due care should be taken in making this very important appointment. Members who are interested in the position or know of members whom they would like to recommend for it are urged to write to President Leedy or other members of the Council as soon as possible.

The symposium on farm ponds which appears in this issue is an innovation and the Editor would be pleased to receive the reaction of readers. If it is favorable, and suitable topics are suggested, other symposia might be planned for the future. Farm ponds seemed to us a particularly apt subject for several reasons. Interest in farm fish ponds is intense but much research which has been or is being conducted is relatively unfamiliar except for the pioneer studies of Swingle and Smith in Alabama.

Reprints of the entire symposium will be available through Secretary Glazener at 50c per single copy, three for one dollar, or ten for two dollars.